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3. Executive Summary

Executed between July 1, 2001 through June 30, 2003, this project sought to evaluate the feasibility of building a regional recycling infrastructure based on 1) the establishment of joint industrial zones where businesses within each zone would use the waste products produced by each other in their own manufacturing processes; and 2) the potential for establishing regional waste treatment and recycling facilities that would take advantage of economies of scale to make recycling more economically attractive.

This approach reflected increased interest in regional cooperation, particularly the establishment of joint industrial zones, following the 1993 Oslo Accords up till the outbreak of violence in September 2000. The overall goal of the project was to determine whether the establishment of regional, economically viable recycling can stimulate economic growth, provide gainful employment, contribute to social stability, and improve the human and natural environment.

The project sought to execute detailed surveys of local waste generation patterns and attitudes towards recycling in the domestic and industrial sectors, complete an economic analysis of the feasibility of recycling different materials based on the data gathered in the surveys, and evaluate the local socio-political/economic situation so as to identify various options and make recommendations that would enable the implementation of steps leading to the establishment of such an infrastructure.

The political and security instability that pervaded the project period encumbered efforts to realize all these goals, however, the project nevertheless succeeded in executing the planned surveys. Accordingly, the overall conclusions of the project are that **future efforts** need to initially be focused in five areas: 1) *developing legislation* that requires appropriate waste treatment and disposal, especially the setting of waste disposal fees; and 2) *establishing enforcement mechanisms* to ensure that the legislation is enacted and applied, especially as regards the payment of disposal fees. 3) *Pilot plant projects* integrating technically-sound waste disposal sites should be established that focus on the recycling of organic waste that composes over 73% by weight of all waste generated. The plants would be sited at locations that would enable them to take advantage of the aggregate waste flow coming from neighboring cities producing at least 30,000 combined tons of waste, i.e. Jenin-Tul Karem-Nablus; Jerusalem-Jericho-Ramallah-Bethlehem; Hebron alone. The plants would produce compost for use by local farmers and for export. However, in order to proceed with these pilot sites, it is first necessary to institutionalize the necessary legislation and enforcement mechanisms; under the current political circumstances, this is not possible.

Additional steps that can be taken more immediately include 4) building a comprehensive, integrated *educational and awareness-raising program* on recycling to maximize participation in future recycling programs. Future participation would thus be encouraged both by appealing to environmental responsibility, and through financial incentives whereby recycling would be a more attractive option to disposing of waste through landfilling or by paying fines for illegal dumping. It is also necessary to initiate projects introducing 5) *environmental management and manufacturing standards* such as ISO 14001 in an effort to make both current practices more environmentally friendly, and make sure that the standards-related infrastructure is in place for future industrial business initiatives once regional political and security stability enables the expansion of such activities as is expected.

As a result of this recently-completed project, the participating institutions have significantly strengthened their technical capacity to execute large-scale projects in general, their technical knowledge in the environmental field in general and waste treatment options in particular, and they now have a very valuable dataset and project report with clear analysis, conclusions, and recommendations for how to proceed once a conducive political situation is realized.

The project partners have worked very closely throughout the project duration despite the very difficult situation that made face-to-face meetings, never mind the execution of politically-unfavorable joint projects, very challenging. Nevertheless, as a result of their close work on this project and agreement on its conclusions and recommendations, the partners are already working together and with other parties to execute various projects identified in the fore-mentioned five areas requiring addressing.

4. <u>Research Objectives</u>

- Evaluate the feasibility of establishing joint, regional infrastructures for recycling of solid, non-hazardous waste in order to create markets of scale that contribute to improving the economics of recycling.

The theoretical basis for this project, formulated in 1997-98, was based on the need for innovative context-relevant mechanisms to enable sustainable regional development that would integrate and address <u>both</u> economic growth concerns and environmental protection concerns, while also taking into account the new political environment that supported and sought to further develop the growing trend and favorable attitude towards regional cooperation in general, and the establishment of bi- and tri-national industrial zones in particular. This basis was further refined based on observations of trends in foreign countries vis-à-vis the establishment of industrial parks whereby symbiotic industries and companies are established within the same park such that one company is able to use the waste products generated by another company in its own manufacturing cycle. By reducing the demand for virgin raw products and creation of waste that needs to be disposed of, overall economic efficiency for both companies is improved while also benefiting the environment. To this end, the overall objective of the project was to evaluate the feasibility of establishing joint, regional infrastructures for recycling of solid, non-hazardous waste in order to create markets of scale that could contribute to improving the economics of recycling. This would in turn allow for the local application of this international trend whereby proposed Israeli-Palestinian and Israeli-Jordanian industrial parks could also be designed to include symbiotic industries and companies. A number of development-related benefits – social, economic, political, and environmental – were/are expected to come out of the application of the research results. These are briefly described below.

In addition,

- Demonstrate/clarify the job creation potential of a local, contextually-relevant recycling industry.

In the local, geographically dense region, land use and environmental preservation is of critical importance as more and more demands are made of the same natural resource base. Not only do limited land and water resources need to physically support an ever-growing population, but these same resources also need to be used in such a manner as to ensure sustainable economic activity to guarantee an income and living for both the current and future local citizenry. With high levels of unemployment and under-employment, job creation is viewed as an imperative whose realization is the key to addressing a host of related issues. A guaranteed income will allow for longer-term planning which has implications for children's and women's education and health, family planning, etc. With a large potential labor force available, demonstrating how job creation through employment in a labor rather than capital-intensive recycling industry was one of the objectives of this project.

- Determine how the establishment of regional, economically viable recycling can contribute to stimulating economic growth and providing gainful employment while simultaneously improving the human and natural environment.

The all-too-common phenomena of random dumping of waste in riverbeds and fields not only represents economic waste in terms of needing to acquire and use virgin raw materials in all manufacturing processes, but it also results in the pollution of soil and underground water ("wasted" natural resources) that further harms the physical health of the local populations. The combination of these two "wastages" impedes and contributes to the challenge of achieving sustainable development for the populations in the region. That is, not only is their economic well-being hindered – or at least not maximized – but their physical health is also damaged. As such, one of the objectives of this project was to determine whether and how the establishment of regional, economically viable recycling could contribute not only to stimulating economic growth and provide gainful employment, but could also improve the human and natural environment at the same time.

- Build a cooperative framework within which both dialogue and active participation and activities could take place.

From a political point of view, because of the geographical density, pollution – whether airborne, through waterways, or by land – crosses borders regardless of political, economic, or socio-cultural differentiation between countries. Accordingly, finding solutions to such problems requires a cooperative approach. In this regard, another one of the objectives of this project was to build a cooperative framework within which both dialogue and active participation and activities could take place, so demonstrating to stakeholders on both sides that citizens on both sides of the political borders are concerned about these issues not as Palestinians or Israeli, but as human beings whose health is equally affected regardless of nationality or religion. Indeed, conversations with people involved in environmental education and awareness-raising projects indicated that stressing the fact that pollution harms the health of <u>people</u> regardless of nationality or socio-economic and/or political standing offers an important mechanism for encouraging cross-border cooperation, thus serving as a bridge for connecting between people of all nationalities, religions, and socio-political backgrounds and levels. [For example, a current Palestinian project has school-children approaching heads of the police, local councils and government, etc. and emphasizing the fact that all people suffer from pollution and therefore need to cooperate to find solutions.]

- Propose an alternative, environmentally-friendly industrial paradigm.

The environmental objectives of this project are clear and varied. Recycling reduces the pressure on existing waste treatment sites, thus lengthening their useful life-times and reducing the need for more sites. Recycling also reduces the need to introduce virgin raw resources into the industrial manufacturing process; this has many implications, ranging from reduced demand at the source of "producing" the raw material and thus decreased environmental degradation at that location, to a net decrease in both systemic and local energy use and air pollution associated with transporting the raw goods from the production site (i.e. mine, forest, etc) to the processing site (i.e. factory).

- Improve stakeholder awareness and reduce potential financier uncertainty.

The project sought to address the multiplicity of problems mentioned above – environmental degradation and pollution, inadequate employment opportunities and market inefficiencies, lack of mechanisms for advancing cooperation and promoting understanding, amongst others – by researching and then proposing a series of recommendations whose application could bring these theoretical benefits to the field. Accordingly, this project was conducted in order to demonstrate how all – or many – of these objectives could be met by exploring and clarifying the desirability and feasibility of establishing integrated industrial parks incorporating symbiotic industries that could both benefit from and contribute to realizing these objectives by operating within a larger regional recycling infrastructure enjoying markets of scale.

Obviously, these objectives represent core goals of sustainable development. However, their complex and interwoven nature is such that, in order to catalyze stakeholders to take action, it is necessary to first reduce uncertainty and lack of awareness as much as possible. While the goals of sustainable development may appear to be clear in themselves, the means of achieving them are very complex, and this therefore required the detailed examination and description of exactly how a given strategy – whether through recycling or through some other means – can realize the individual goals that compromise sustainable development.

<u>Innovative Aspects of the Project</u>

This project focused on four key innovations, described below in further detail:

1. The establishment of a regional industry leveraging economies of scale versus localized initiatives relying upon entrepreneurial vision to enter small, local market niches
2. Use of decentralized and modular technologies at or near the site of waste production/collection versus building and operating centralized plants

3. Designing-in of symbiotic technologies and industries during development and planning stage of industrial zones versus band-aid, post-facto remedial approach to dealing with waste generated by various sectors
4. Combined NGO and private sector-led initiatives versus relying on the public sector to initiate and/or provide waste treatment services

Innovation # 1

One corner-stone of this project involved adopting an approach oriented to identifying potential economies of scale in recycling to take into account the low marginal value of recycled materials other than through centralized treatment/recycling plants. Recycled material per unit has only a slightly higher value after accounting for all costs associated with recycling the material due to relatively high logistic (collection and sorting) and treatment (capital and operational) costs. As such, investments by or on the behalf of locally-oriented *independent* businesses to recycle waste produced, treated/recycled, and then re-absorbed by the local manufacturing base only may be prohibitively expensive due to high logistical and capital/operational costs. For example, ten recycling businesses operating independently throughout the region that individually purchase the same or similar equipment would not be eligible for the same bulk-purchase discount for that equipment that one unified body "representing" or integrating all ten businesses may enjoy. Alternatively, high initial capital investment requirements may result in a return of investment period longer than would be seen as representing a viable financial investment for a private investor.

From the public sector point of view, limited budgets preclude public sector bodies from investing in the necessary infrastructure to engage in decentralized recycling, even if such an approach may potentially offer greater social, environmental, and/or local economic benefit, although at a greater initial monetary cost. Such benefits, amongst others, may include wider dispersal of employment and income-generating opportunities over a greater geographical area, reduced transportation-related pollution, and increased and more equitable local capital generation and spending. Accordingly, the public sector may view centralized plants as offering the more economic – under certain circumstances that do not take into account externalities – option that also offers more immediate political payback in the form of a significant, visible contribution to the local constituency. In light of the very difficult economic situation in Israel and the Palestinian National Authority areas – both due to the global recession and the ongoing security conflict – the lack of public sector funds on both sides for such investments makes government investment a non-option, while market uncertainty and security instability make such investments unattractive to private investors as well.

Accordingly, an alternative (or possibly complementary) option that redefines the economics of recycling is viewed as necessary, both in terms of the approach to creating the physical infrastructure, as well as alternative business models. This approach, further developed in innovation #2, proposes the establishment of a unified regional business framework within which "nodes" or smaller business recycling different, specific materials could work together through an integrated marketplace or business framework structure.

This could increase efficiency through effective transfer of information within one organized infrastructure, and increase economic viability by allowing for bulk equipment purchases and sale of recycled and recyclable materials within the same framework, that is, create a market of scale that could increase profit margins by partially compensating for the initially low marginal value of the materials.

It is important to note that, while the introduction of social and environmental externalities into the equation would increase the value of the recycled material versus the production and distribution of similar virgin materials, such externalities are 1) not included in the costs of manufacturing virgin goods and therefore excluded in the evaluation of recycled materials, and 2) not easily quantifiable in monetary terms.

Innovation # 2

The second innovation that guided this project developed as the research into methods for recycling different materials proceeded. Generally-speaking, the emphasis changed from one that focused on identifying different kinds of recycling technologies and technical processes, to one that sought to identify the most appropriate scale of organization and technology. That is, the focus shifted from examining different technology options and technical processes for recycling the various waste stream materials (grinders, shredders, compactors, etc.) to identifying the most appropriate approach to recycling, i.e. the scale of technology and organization that would be most relevant in the local context. It became evident that, in light of the cultural context vis-à-vis distribution of populations in a few centralized urban centers and many dispersed villages, financial limitations (lack of public sector budgets and private investor hesitancy to invest), logistical considerations, and the political/security environment, small-scale, decentralized, modular technology-options were the most desirable. In particular, it became apparent that certain technologies could be used in both waste treatment and power generation applications to offer added-value services for both service infrastructures. This approach, discussed below, is particularly relevant in the local context for several reasons (cost, project sustainability, technical reliability and appropriateness, cultural relevance and desirability, organizational longevity, need for significant infrastructural development and rehabilitation, etc.) and is therefore identified as being a potential stage two project with significant potential for application in the field.

The need for this innovation is further reinforced by the following two observations over the last 3 years: 1) the dire need in the Palestinian Territories for significant investments in development, repair, and maintenance of both the waste and energy infrastructures, quickly made evident the existence of a potential synergy whereby certain technologies could be leveraged to offer solutions to both waste treatment/recycling, and energy generation, so addressing two ends through a single means; and 2) with such a significant proportion of waste generated in the target area consisting of organic waste, such an approach has the potential to make a significant impact on both the physical environment (less waste to be treated/removed), and the human environment (direct and indirect job creation). In light of this, the application of waste-to-energy incineration, waste-to-biogas processes, or waste-to-compost offer three options that are further discussed below and in section 9 on future work.

Under the present conditions, modular decentralized technologies appear to offer numerous advantages over central, large-scale technologies and sites. First, they can be located at or near the source of waste generation and potential re-use after recycling. This is particularly important in light of the need to, on one hand, address issues of waste treatment immediately, while on the other hand take into account considerations borne of political and security uncertainty. Unpredictable closures and curfews prevent plant managers from being able to plan operations that rely on receiving and transporting waste to be recycled, and/or recycled materials from being shipped out. Centralized facilities are therefore more difficult to plan and operate, making them unattractive and risky initiatives. As mentioned above, however, an attractive option is the generation of biogas by anaerobically decomposing organic waste at *local* dispersed organic waste collection sites such that the decomposed waste can be used as liquid fertilizer and the biogas burned in small-scale microturbines located on-site to generate power.

Organic waste decomposition sites that integrate biogas-burning power generation units (with the appropriate emission controls) that are scaled to the needs of, and located closer to the population center being served, obviates [to some degree] the need for long-distance transportation of waste, reduces reliance on external markets [that supply the waste], and creates a more robust local power and waste treatment infrastructure that also provides local employment even under difficult political and security conditions. As such, overall systemic reliability and efficiency is improved. Furthermore, the loss or destruction of one node that is part of an integrated, multi-nodal system does not mean that the entire system collapses.

From a business or organizational perspective, the ability to locate the systems in or around a cohesive population center allows for taking advantage of interpersonal relations and local politics to form a stable business/system operating framework. This organizational stability and longevity can serve to ensure, or at least increase the chances of, project sustainability – if not profitability – after initial funding is arranged.

Another advantage of these technologies is their financial attractiveness. Being modular, they require smaller capital investments and can be augmented and expanded, with additional units or nodes being added over time as capital becomes available or market forces dictate. This enables a quicker return on investment for the financier and so makes such an investment more attractive and less risky.

Innovation #3

The third innovation incorporated into this project sought to "test" the feasibility of an industrial ecology paradigm whereby industrial zones are planned and developed taking into account the possibility of establishing businesses and industries that could utilize the waste generated by one business in the manufacturing process of another, that is, a symbiotic relationship between companies. The potential benefits to the companies directly involved would include reduced waste treatment/disposal costs and reduced expenses associated with purchasing raw materials for manufacturing, while improved overall systemic operating efficiency would result in reduced energy consumption per unit produced, reduced transportation-related pollution and congestion, and associated macro-level environmental and social benefits.

With the growth in interest in the establishment of joint Israeli-Palestinian and Israeli-Jordanian-Palestinian industrial zones in the mid- to late 1990s following the signing of the Oslo Peace Accords and prior to the outbreak of the current uprising (Intifada), it appeared that the results of this project could be of particular relevance, interest, and applicability for such joint industrial zone initiatives. While the current Intifada has relegated such initiatives to the back-burner, the research executed during this project has strengthened the conviction that the application of industrial ecology in the form of symbiotic technologies – and not just symbiotic industries – is indeed relevant, and, for the reasons mentioned above, all the more relevant in the current situation of crisis (due to system robustness, decentralized and modular design, etc.). For example, the realization that the application of biogas-operated "gensets" (generator sets such as microturbines) can provide [in relevant locales] a unified package-solution to both certain waste treatment and energy generation needs in an area in dire need of such solutions is a significant and important confirmation of the validity of the industrial ecology approach proposed in the initial project proposal. Perhaps even more significant in terms of future work is the recognition that this industrial ecology approach advancing symbiotic technologies and industries has the inherent flexibility and adaptability to maintain context relevance even as circumstances change significantly as has occurred over the last 2.5 years. In the local case, relevance and applicability are demonstrated (albeit in theory at this stage) even under the most difficult physical and political circumstances through the use of modular, decentralized biogas-operated microturbines powered by the methane gas generated during the decomposition of organic wastes in order to provide electricity, and potentially also heating and cooling a well. This approach may thus offer the ideal solution to some service-infrastructure-related problems (i.e. reduced or lost power or waste management services) that have yet to be resolved through other more traditional means or approaches.

Innovation #4

The fourth innovation that guided this project was the hypothesis that a combined NGO-private sector-led initiative to provide the analysis of services [and ultimately provide the service itself] typically provided by the public sector, or whose provision by the private sector is dictated by a public-sector initiated tender, would allow for a more socially and environmentally balanced analysis that would not be [as] encumbered by political considerations and obstacles. This assumption was based on observations regarding the on-again off-again diplomatic process and negotiations between the Israeli government and the Palestinian Authority, to the on-going detriment of the citizenry and environment that are forced to wait for a political solution while the physical and human environment continued to degrade.

While the assumptions underlying the political saliency and desirability of using an NGO-initiated framework do indeed appear to have been justified as evidenced by the continued desire and efforts on the parts of all partners involved to continue work despite the interruptions caused by the political-security situation, the severity of the ongoing economic crisis in Israel (and globally) made it unrealistic to expect private sector companies to want to participate on an on-going basis on a project whose fruits would only be seen in the long-term while the company's have to focus a majority of time and resources on short-term quarter-to-quarter concerns and challenges. Furthermore, the security situation and uncertainty it raised – both on the personal emotional level (mistrust, skepticism, fear, etc.) as well as in terms of business planning (inability to engage in logistical planning in such a fluid situation) – further contributed to making it unrealistic to propose cooperation to establish a large scale joint recycling infrastructure as originally envisioned; such a vision was felt by the partners as flying in the face of the reality on the ground and could undermine the credibility of the project and partners involved.

Despite this – or perhaps as a result of this – the focus changed to identifying those opportunities that could be viably executed specifically in the most difficult of situations and even provide an attractive business opportunity, even if not as originally envisioned or intended. Furthermore, while the original private sector stakeholders and companies became less relevant in terms of a second stage of this project – application in the field – a new set of partners and stakeholders has been identified.

Integration into work by other scientists, institutions, etc.

This recently completed MERC-funded project is very timely in terms of its completion shortly after the UNEP published a desk study documenting the state of the environment in the Palestinian Territories, including literature surveys on the state of solid waste. The findings of the MERC project add valuable detail to the general findings and recommendations of the UNEP study, with both reports confirming the findings of the other. Furthermore, the project proposed as a follow-up stage 2 to this MERC project (described in section 9) also addresses issues raised and recommendations made in that same UNEP report.

5. Methods and Results

[The detailed results of this project can be examined in the accompanying materials, including a full Excel database of the various surveys and the solid waste composition and distribution, and the economic analysis of various options.]

The methodology for each of the research surveys was prepared over the course of several meetings between the different co-principals and institutions. Several changes were made to the original research methodology in order to increase the feasibility and relevance of this research. These changes primarily dealt with the number of the sites and the way data is being collected. It was decided to cover 64 sites distributed between districts according to their population (described in the table below) instead of 48sites, with 6 sites for each district. It was also decided to collect data on more than days per months than the originally intended 4 days per month.

The outlines of each survey methodology, the domestic waste composition analysis, industrial waste composition and social aspects of the solid waste, are as follow:

Domestic waste composition analysis:

1) This part of the survey started with complete preparation to identify and recruit the students who would participate in the training workshop. The students were from the Science and Technology College in Jerusalem.
2) Training workshop was held to prepare the students to execute the in-the-field domestic waste analyses (weighing, separation, etc.), various industrial waste surveys, and questionnaires.
3) 13 students who had expressed interest in joining the project were recruited, the PIES office administrator provided each student with a broader picture of the nature of the project and the work it would entail.
4) All technical and logistical matters were coordinated with the trainer, Mohammed Said Al Hmaidi, former Director General at the Ministry of Environmental Affairs and USAID Solid Waste Expert. A manual, both in Arabic and English, was prepared by Mr. Hmaidi, and printed at PIES for dissemination to the participating students. The manual covered the following subjects relevant to carrying out the field survey:
   - General introduction to solid waste management in the West Bank;
   - Appraisal of the solid waste problem;
   - Role of public involvement and public relations vis-à-vis solid waste management;
   - Institutional, financial, planning, training, human resources and employment issues;
   - Technical aspects of solid waste management.
5) Following this workshop, the students began their fieldwork for the domestic waste composition analysis in November 2001. The collection of data ended at the end of October 2002. Each of Bethlehem, Jericho and Jenin districts had one field researcher while the remaining districts had two.
6) It was decided to choose 64 sites, as follows:

	Place of living			
	Urban	Rural	Camp	Total
Bethlehem	8			8
Jerusalem	6			6
Hebron	8	5		13
Ramallah	3	3	1	7
Jericho	2	1	1	4

Nablus	3	4	1	8
Tulkarem	6	3		9
Jenin	9			9
Total	45	16	3	64

Note: 2 of the Bethlehem sites belong to the project coordinator and executive manager of WEDO to be used as control sites.

7) The sites were chosen randomly, at the beginning it was difficult to find families who were willing to participate in this survey but over time the researchers convinced the above families to participate in this survey.
8) It was arranged to collect data concerning the domestic waste composition analysis on weekly basis. However the families varied in the way they disposed of their waste: all of them agreed to dispose of glass, plastic, writing paper, metal and others waste on weekly basis. While disposal patterns of the organic and toilet papers were varied between families; most of them did it for the last 48 hours of the week while others did it for all the week. The data, in the end, was standardized to represent a weekly disposal basis. This methodology was based on a 12-month cycle that allowed for seasonal variation.
9) Regular bi-weekly follow up meeting were done with the students at the Science and Technology College in Jerusalem.
10) The domestic solid waste data was then entered into a database and analyzed using Microsoft excel and SPSS programs.

Social survey
The social survey covered 109 families; 52 of them were the families of the survey. The distribution of the families between districts described as follow:

Number of families distributed between districts

Area of study	Place of living			Total
	City	Country	Camp	
Hebron	11	14	1	26
Bethlehem	6	2	1	9
Jerusalem	6	2	2	10
Rammallah	10	3	2	15
Jericho	1	2	6	9
Nablus	5	4	1	10
Tulkarem	7	6		13
Jenin	14	2	1	17
Total	60	35	14	109

The students were randomly assigned the families they would be covering as part of this survey. This social survey, consisting of a questionnaire, covers information concerning the families' knowledge, practices and attitudes towards reuse, recycle and separation at source of solid waste. The results of the social questionnaires were then also entered into a database and analyzed by using SPSS program.

General information about the survey participants

1- Place of living: 55% of the participants live in a city, 32.1% lives in the country and 12.8% of them live in camps.

2- Geographical nature of the participants living areas: 59.6% are living in the mountains, 25.7% are living in the plain, 5.5% are living in the valley, 8.3% are living in Al Ghor, 0.9% are living in desserts.
3- Level of education of the responsible person at the family: 6.4% were illiterate, 11.9% have elementary level, 22% have secondary degree, 59.7% have either collage or university degree.
4- Number of workers at the family: two families have no workers, 53.2% of the families have only one worker, 33% of them have two workers, while .7.4% have more than two workers.
5- Family income: 6.4% of families have income less than 1000 NIS, 33% have income between 1000-2000 NIS, 93.6% have income more than 2000 NIS.
6- Solid waste collector side: 93.6% of the participants said that either the municipality or village counsel were responsible for collecting solid waste.

Industrial sector surveys

First, a questionnaire gathering information was prepared, addressing general information about the factory, raw materials needed for the industry, products of the factory, generated industrial waste, means of waste disposal, recycled / reused products, knowledge about reuse / recycling of products and by-products.

Second, 10 categories of industries were identified: metal industry, food industry, stone & glasses industry, leather industry, wood & furniture industry, paper industry, chemical industry, clothes industry, plastic industry and electrical equipment industry.

The 154 factories covered by this survey were distributed between the districts as follow:

District	Number of factories
Hebron	29
Bethlehem	32
Jerusalem	19
Rammalla	27
Nabuls	9
Tulkarem	8
Jenin	19
Total	154

Note: Nablus and Tulkarem have the least number of factories as the result of the difficult political situation these areas had during the last year.

<u>Research results</u>

Domestic waste composition analysis:

1) Average solid waste weight per capita per day for research families during the year 2002 was 309.18 gram.
2) Average solid waste weight per capita per year for research families during the year 2002 was 167.45 kilograms.
3) Organic solid waste is the most abundant type of waste that the families produced; 71.93% of solid waste weight was organic. The table below shows the average solid waste weight per capita per year for each item of solid waste for all families:

Solid waste item	Average/capita/year Kilograms	%
Plastic	36.71	2.74
Glass	16.48	1.23

Metal	27.56	2.06
Writing Paper	41.27	3.08
Toilet Paper	167.17	12.48
Organic	987.414	73.71
Other	63.033	4.7
Total	1339.637	100

4) The highest average solid waste weight per capita per day was for Jericho families 842 grams, while the lowest was for Nablus families, 321 grams.

The following table shows the average solid waste weight per capita per day & per year and total solid waste weight per year per district.

District	Average solid waste weight/capita /day/ Gram	Average solid waste weight/cap/year/ Kg	Total solid waste weight/district/year Kg
Hebron	556	202.789	102549.16
Bethlehem	394	143.819	24350.96
Jerusalem	434.4	158.425	62435.92
Rammalla	418	152.654	44243.35
Jericho	842	307.242	12564.36
Nabuls	321	117.29	52119.787
Tulkarem	336	122.795	31205.25
Jenin	369	134.591	33284.94

The table below shows the solid waste weight for each item of waste that each district produced during one year based on the survey executed in this project. It is important to not that this survey was executed during the very difficult military and political situation in the region at the time. The population numbers were taken from the Palestinian Central Bureau Statistics.

Generated Solid Waste
Ton/Year

	Bethlehem	**Hebron**	**Jerusalem**	**Rammallah**	**Jericho**	**Nablus**	**Tulkarem**	**Jenin**	**Total**
Plastic	1062.06	966.06	3547.25	1903.95	243.51	1631.771	529.27	309.25	10197.361
Glass	387.11	1119.55	761.15	1461.41	71.45	467.934	448.24	112.01	4828.894
Metal	613.41	1001.49	1255.98	1339.81	247.1	1120.731	1105.66	306.07	6987.291
Paper for writing	1325.26	1273.44	2596.32	1818.92	298.35	939.868	1622.34	556.72	10431.218
Toilet paper	2479.65	14205.79	10217.25	4655.95	841.03	14913.015	5909.7	1247.04	54469.425
Organic	17506.16	83791.39	43672.31	33025.49	8734.97	33009.584	21411.894	30024.53	271176.32
Other	977.31	191.44	385.66	37.82	2127.95	36.884	178.142	729.33	4664.536
Total	24350.96	102549.16	62435.92	44243.35	12564.36	52119.787	31205.25	33284.95	362755.05

5) The results indicate that there is only minor seasonal variation in the quantities of solid waste generated by weight between winter and summer seasons. The table below shows that average solid waste weight during the summer season per capita per day is 45.31 grams higher than in winters.

Table showing the average solid waste weight per capita per day for survey families during winter and summer time:

District	Average/ capita/ day Winter (grams)	Average/ capita/ day Summer (grams)
Hebron	642.18	659.5
Bethlehem	417.45	431.87
Jerusalem	504.97	432.58
Rammalla	501.85	564.45
Jericho	679.89	821.47
Nabuls	375.189	341.86
Tulkarem	336.72	412.86
Jenin	287.25	461.69
Hebron	461.99	507.3

6) The highest average organic waste per capita per year was for Jericho families, the Jericho families produced 22% of the organic waste. Nablus families produced the least amount of organic waste.

Social Survey Results

Results of the social survey showed a poor level of knowledge concerning reuse and recycling. For example, answers to questions number 16 & 17 " Do you have knowledge or information about waste recycling and reuse?" were as follows:

- 49.5% said they do not have knowledge about reuse while the rest said yes they know what reuse is and gave a short explanation about it. These explanations varied as follow:

1- 13.9% of yes answers said reuse is converting organic waste into composting.

2- The rest of the yes answer were about reusing glass, plastic, bottles, cola tin, food containers, metal containers, plastic bags and so on.

- 51.4% said they do not have knowledge about recycling while the rest said they do know and gave a brief explanation that recycling relates to paper, toilet paper, plastic, cola tin and glass, metal and so on.

- 77.8% of the answers to the question if they know of what natural fertilizer is composed were positive; of them 31.8% said it is composed of animal waste, 7.1% said it is composed of organic waste and 16.7% said it is composed of animal and organic waste.

- More than half of the participants (55%) have no knowledge about countries engaging in recycling projects of solid waste. However the participants who said they do know of countries that recycle mentioned European countries and Israel. A few also said Japan and USA.

- The answers to question, "Would you agree to do waste separation" were encouraging since 80.7% of them said yes. On the other hand, the ones who said no (13.7%) gave reasons such as: no containers and/or factories for such things; no space at home; can't do it; it requires too much effort; or there is no need for doing it.

- 88.07% of the cases (96 cases) said that they would agree to use recycled or reused products; of them 29.2% said that they agree to use all kind of products, e.g. glass, metal, plastic, & paper. The rest of the yes answers are clarified below:

Reused and recyclable waste products that that survey participants agree to use, by type

Products	Number of participants willing to use the mentioned recycled/reused item	Percentage of total surveyed
All	28	29.2
Glass	13	13.5
Glass, metal	2	2.1
Glass plastic	5	5.2
Glass, plastic, metal	5	5.2
Metal	3	3.1
Paper	13	13.5
Paper, glass	3	3.1
Paper, glass, metal	1	1.1
Paper, metal	4	4.2
Paper, plastic	5	5.2
Paper, plastic, metal	1	1.1
Plastic	3	3.1
Plastic, metal	2	2.1
Other	3	3.1
No answer	5	5.2
Total	96	100

- The results to the question asking for clarification as to why recyclable products should be used show that protecting the environment was the most important reason for accepting using recyclable products (33%) followed by the need to decrease the amount of waste generated (14.7%). The percentage of those surveyed who stated both these reasons together was 13.8%. The following table presents the answers to the question "What things encourage you to use recyclable products?"

What factors encourage the use of recyclable products?

	Frequency	Percent
No answer	3	2.8
Decrease amount of waste generated ("waste size")	16	14.7
Decrease waste size & save money	1	0.9
Protect environ	36	33.0
Protect environ, decrease waste size	15	13.8
Protect environ, save money	2	1.8
Protect source	6	5.5
Protect source & environ	2	1.8
Protect source & environ, decrease waste size	1	0.9
Protect source & environ, decrease waste, save money	7	6.4
Save money	20	18.3
Total	109	100.0

Discussion and Conclusions:

It is important to mention that the year in which this research took place was one of the most difficult experienced by the Palestinian people. During this year, the Palestinian people were exposed to extreme political and military situations that caused huge pressure on every aspect of their life, especially the economic side. There were long sieges, closures and periods of fighting that caused a decrease in employment in general, and especially in the number of laborers allowed to enter and work in Israel. There was also a decrease in industrial production, a decrease in food production and exporting, a decrease in trade and so on. All these factors affected the standard of living and caused an increase in poverty.

These facts are very clearly reflected in the domestic waste composition analysis that shows a decrease in the average solid waste weight per capita per day (416.8 gram) for those areas most centrally involved in the Intifada as compared to the overall national average (800 – 1000 gram).

There is some variation in the average solid weight per capita per day between districts, which strengthens the above claim that the political and security situation had a direct role in the determining the amount of waste generated. The Nablus, Tulkarem and Jenin districts were exposed to the above political and military situation more than other districts, a fact that is reflected in the average solid waste per capita per day for these areas, respectively 321 grams, 336 grams and 369 grams, all below the national average even during this period. On the other hand, the average was much higher for Hebron districts - 556 grams – with this being due to the fact that Hebron district wasn't as greatly affected by this situation during the year 2002. On the other hand the average was very close to the national level for Jericho district - 842 grams - since this district was not affected at all by the political situation and the people their lived life as normal as possible.

The Palestinian people are well known for their food-purchasing practices that lead them to spend more money on food products especially fresh produce, since the country is rich with agricultural lands. Also, they have very close familial relations and big families, and big meals are considered one of the primary traditional practices used to strengthen the relationships between and within families. This is also shown in the survey results, with organic waste comprised the highest percentage of waste items - 73.71%; this leads to the need to emphasize the importance of projects dealing with composting. For example, Jericho is well known as agricultural country with very high production of citric fruits and banana that produce large amounts of waste from the peals. This is one of reasons Jericho district had the highest percentage of organic waste - 22%. One of the finding that the research showed is that the organic waste for Jenin families composes 93.29% of waste.

Rammalla district is well known for its highest number of government and NGO's institutions and offices that consume drinks and food prepared in glass. Data showed that 31% of solid waste by weight was for families from Rammalla that use these heavy packaging products.

The social study showed some promising and encouraging results vis-à-vis organic waste; 77.8% of all the survey participants said they know what is composting and how it can be used. It is important to note that 55% of the survey participants were living in agricultural areas, and a high percentage of them had some familiarity with the subject. Also 88.07% of those surveyed agreed to use recyclable products and 62.5% of them said they approve of using recyclable products in order to protect the environment, decrease the amount of waste generated, or for both reasons. It is also important to notice that 80.7% of them approved of and indicated a willingness to separate waste (i.e. separate organic and non-organic waste) at their houses. These results are particularly important and can be used in future projects and initiatives to develop a recycling industry that includes at-source separation.

On the other hand the knowledge of the participants on questions dealing with recycling and reuse industries was not high. The answers were brief and not clear; this indicates a need for future awareness raising and education activities to increase the knowledge of people about the different industries that can help in overcoming environment problems.

6. Impact Relevance and Technology Transfer

Usefulness in ME: The project partners see three particular uses for the findings of this project.

1. Database for future research
2. Catalyst for future business development when the situation enables or as becomes relevant
3. Enable the immediate initiation of pilot projects based on the data gathered [following further technical analysis and planning] in integrated organic waste composting and power generation projects, technology transfer, and environmental standards and regulations [See "Possible Future Cooperation Programs" below for more information.].

Regarding the *database for future research*, the raw data gathered will be useful in future research analyzing trends, and the implications of those trends, in waste generation throughout the survey area. Furthermore, as the data represents an accurate sampling of the area – data previously gathered did not employ this year-long surveying technique – it also offers a further refinement of previously less detailed surveys.

Regarding *the catalyst for future business development*, the data gathered offers a micro-picture of the potential market for waste management-related business opportunities from both the demand and supply perspectives, and is therefore a valuable source of data in this regard. As the sector is in need of significant investment to improve the level of waste management service, such data made readily available to local entrepreneurs can stimulate investments in, and improvement of, the local waste management sector.

Regarding the *initiation of pilot projects based on the data gathered*, and as related to the above point and also mentioned in section 9 on future work, a project proposal has been developed to further investigate the potential of wide-scale integrated composting/power generation business opportunities based on pilot demonstration sites for which international funding is being sought. See also below in "Possible Future Cooperation Programs" below.

Impact on individuals, labs, dept's, and institutions

On the *individual-personal level*, this project has had a positive impact by creating an on-going framework based on a common non-political interest/goal that all the partners believe in on the personal level. This is important because it allows the people involved to come to know one another not just within a politically oriented framework that has "forced" them to come together whether they want to or not, but rather because the issue is one that is important to each person on a personal level and for this reason they have dedicated themselves to finding a solution. Building the project framework on a common interest and passion (environmental protection) enables a more "emotional" bond to develop, and so also enables – even encourages – people who want to be in contact to do so despite the obstacles, and for communication to be continued between the people on the two sides even during the most difficult of times in terms of the political-security situation. The framework allows for discussion and the airing of feelings, problems, hopes, support, and exasperation with the effects of the macro-situation on the individual. This ability to express the personal feelings to the other side and by so doing increase the other person's awareness – regardless of whether Palestinian or Israeli – is the key to building an understanding and personal connection upon which joint cooperative professional work in other fields can then be executed on a basis that goes beyond simply working together as emotionally dislocated and detached professionals, but rather as two people between whom there is a deeper understanding of the personal motivations.

If during this critical and tense political period in the Middle East researchers were able to meet, it would appear that efforts related to the pursuit of knowledge, know how, and technology-transfer do not recognize political differences in the region. Furthermore, it also re-confirms that even under these extreme conditions there are researchers and scientist who are still willing to work together at a regional level.

In addition to improving the personal relations between the partners, the project has also allowed for the individuals working at the respective institutions to improve their technical proficiency in the field. This includes a greater knowledge of the specifics of the issue, increased appreciation of the complexity of the issue, and widened exposure and awareness of other fields and subjects that have an impact on the issue at hand and therefore need to be taken into consideration. The aggregate of all this is a more analytical thought and evaluation process on the personal level, which accordingly allows for more professional and effective execution of this or any other work. This is particularly relevant vis-à-vis exposure to business-related thinking, which has not historically been a core focus or proficiency of the NGO partners involved in this project on either side. This exposure and heightened appreciation for the need and ability to take into account profit-loss and other financial and business factors (based more on monetary considerations) clearly complements the other social factor-related skill sets (which may be less based on monetary considerations) with which the partners are more familiar, thus giving the individuals a more rounded analytical and evaluation ability and so making them superior assets both on the personal level and to their respective institutions. The net effect of this is that the capacity and ability of the institutions to engage in similar projects is improved as the human capital available is of higher quality with a wider skill set and greater capabilities.

- Will results be used? How? By whom? When?

As discussed in section 6 above on Impact Relevance and Technology Transfer, the conclusions and recommendations made based on the data gathered from this project are already being applied in the form of a proposal for the establishment of decentralized organic waste decomposing sites for the generation of biogas for use in microturbines to generate power and heat, with the liquid by-product to be distributed throughout the local economy as fertilizer as is economically feasible. This proposed project represents the second stage (execution) of the feasibility study supported by the USAID MERC program that has just been completed. The participants in this second stage will include the same participants – The Truman Institute, PIES, and WEDO – as well as other academic institutions, the Israel Electric Company and Palestinian Electric Company, and other private sector and civil society partners as relevant.

In addition, a separate proposal for the social, environmental, technical, and economic feasibility of distributed power generation assets in the Palestinian Territories independent of the waste infrastructure has already been prepared and submitted for funding, with a response pending. This project will be led by an engineering consultancy group on the Palestinian side, working with several Israeli consultants associated with this recently completed MERC project.

- Are large scale trials warranted?

Large scale trials are warranted in particular for the integrated organic waste-power generation proposal described above. It is assumed that there will first need to be a process of establishing a few small demonstration sites for proof-of-concept before large scale application can be achieved. The decision to ramp-up application beyond isolated demonstration sites assuming positive results are achieved will be determined by the response to the proposal from all stakeholders involved, and the ability to access the necessary capital.

Already, a number of municipalities and industries, as well as the Chambers of Commerce, have confirmed this and expressed interest in expanding recycling and reuse activities and initiatives. It is also the policy of the Palestinian Environmental Authority to proceed with larger-scale specific trials at some stage. All have shown some level of interest with the project methodology and findings. Therefore, the final report shall be shared with all related bodies.

However, to make such pilot projects feasible and relevant as models for future wide-spread application, it is necessary to ensure that they are economically sound. This requires either long-term financial commitments from the international donor community, local financial commitments to subsidize the site's operation, or the institutionalization of legislation and enforcement of waste disposal fee collection to fund the site's operating costs.

- What difference has the project made?

The project has made a difference and had an impact on several levels – personal, institutional, regional, and environmental. The personal and institutional impacts are described above.

In addition, the technical waste composition and social surveys are the first of their kind to actually examine the household-level waste generation and disposal patterns, as well as attitudes by individuals and businesses regarding waste generation and disposal. The availability of this database will be important for projects initiated by other institutions and stakeholders addressing solid waste treatment, as well as for the project partners for this project in the follow-up project described in section 9 on future work.

Furthermore, while the project has now been completed, amongst the researchers who were trained are those now in the process of completing their university degree in this field, or are examining the possibility of entering into the field – whether through business or academia, and some of the industries that were involved in the various surveys are now looking into further steps.

The outputs of this project also have the potential to impact at the national and regional level To wit, the Barcelona Declaration's three main goals which were developed in the November 1995 Ministers meeting were:

1. A definition of a common area of peace and stability through reinforcement of political dialogue and security
2. A rapprochement between peoples through a social, culture and human partnership;
3. A construction of a zone of "shared prosperity" and a gradual establishment of a free trade zone through the region, to be fully functional by the year 2010.

As increasing the trade between the West Bank and the Gaza Strip and the rest of the world which is currently very small if not the smallest of any Mediterranean country, and the establishment of free trade zones between the EU-Med countries [as well as between the United States and the region] are all ambitious objectives that all regional countries are aiming for, it is only logical to conclude that <u>any</u> technical or institutional development or improvement in the region can make a solid contribution in the regional countries vis-à-vis preparing for future cooperation with the EU, U.S., and other Med countries. Although the overall project was limited in scope and coverage, the output and recommendations– if considered and implemented by authorities and institutions – can serve as one of the catalysts for this preparation.

Based on the above, all project findings, recommendations and output shall directly and positively affect those who were involved, whether individual researchers, institutions, or the industries included in the survey. The reason for this is that the area (West bank and Gaza) is still developing standards, regulations and know how, therefore any knowledge or technology transfer shall have both an immediate impact on the level of technical sophistication, as well as a long term impact on the on-going capacity building process that is critical for ensuring future competitiveness and capability.

Clearly, every country in the region has the desire to strengthen its sphere of influence within the area, and one way of doing this is through ensuring opportunities for establishing profitable interests in the Mediterranean market. At the same time, reaching a significant level of exports can only be achieved by adopting regional/ international standards, and having a widely-accepted set of methodologies and approaches to enable reaching these standards will contribute to facilitating the achievement of these standards. While it is still true that this project was limited to recycling potential, this also involved expanding the knowledge-base regarding waste management at large, pollution prevention, and standards and regulations; all these are key issues in any sector, not just recycling.

Most West Bank cities are developing Solid Waste Management Plans, to be followed by the implementation of solid waste systems. These are costly, and require input from all related persons, departments and institutions. The findings derived through this project can save time and effort for all interested municipalities; they do not only give answers to municipalities, but also directions for future work. This can help strengthen their understandings and put them in a better position for entering into financing negotiations with relevant bodies regarding possible assistance for solid waste systems.

In addition to the individual researchers and the institutions that benefited from this project, another beneficiary is the industry. As stated above, it is a requirement that all industries planning to be part of the free trade zones upgrade their environmental management systems, of which waste handling is a key component, and waste recycling and material reuse is a key elements in realizing success in this field.

Finally, and as stated above, one can only find hope in the fact that, despite the very taxing political and security circumstances that existed during the course of this project, researchers were ready and able to maintain contact with one another and continue to cooperate to advance the various activities that comprised this project. The readiness of individuals and institutions on both sides to continue to work together uninterrupted speaks to the importance of developing projects – in all fields – based on robust mechanisms and mutual goals and interests in order to enable and encourage cooperation even under the most challenging circumstances.

Expected positive environmental impacts.

Environmental impacts of the implementation of future projects based on the recommendations generated through this project cannot be generalized but rather depend on the particular circumstances of industrial, farming systems, municipal actions, and other factors. They may include:

1. Higher environmental awareness and standards;
2. Transfer of environmental technologies and increased technical assistance and financial aid in environmental fields;
3. Opening markets for environmentally friendly good such as organic agriculture or products receiving eco-label certification;
4. Better handling of industrial waste starting with waste minimization
5. Better management of the region's scarce resources;
6. Better use of land once waste minimization is practiced.

It is important to remember when considering these expected benefits that regardless of the future regulatory standards that may be put in place, further exploitation of natural capital may be inevitable, whether to address balance of trade distortions by the central governments, or simply as the result of everyday survival practices by local populations. The extent of this exploitation, and its impact on the sustainability of the industrial and agriculture systems that are part of any given trade liberalization paradigm depends on the capacity of local government to maximize reachable benefits and minimize negative impacts.

Forecast Impact on Industry

It is still safe to say that the industrial sector contribution to the gross domestic product in the West Bank and the Gaza Strip is very modest. This is estimated at $ 170 million USD, and the relative share of GDP is about 18.92% (UNESCO report on economic and social conditions in the WB and the GA, 1998). It is true that this sector employs almost 70000 workers in the various industries, but it still faces some major difficulties including the location of these industries. Almost one third of West Bank industries are within residential areas and almost another third (in some districts) are within agricultural areas. Development of such industries will come at the expense of the public health or right to enjoy reasonable living conditions. Development of those industries within agricultural areas, as is the case now, will have its negative impact on agricultural land area availability and quality.

The way to evaluate the possible impact on the industry in Palestine covers a wide range of possibilities and may lead to a number of policy decisions. At the early stages of building the [proposed] Industrial Estates all over the West Bank and the Gaza Strip. (Gaza, Jenin, Tarqumia, Tulkarem, and Nablus), it is very likely that careful consideration will be given to the choice of industries and technologies applied within the framework of regional agreements (once made). The data gathered through this project can play an important role in determining which industries, technologies, and policies should be advanced.

7 Project Activities and Outputs

Surveys: The specific technical activities executed as part of the industrial, social, and waste composition surveys, are described in section 5 (Methods and Results). The training manual is included in this final report. In addition to the data gathered through the specific surveys, the industrial institutions and the relevant ministries were contacted to get their data, findings and any other relevant materials of use in order to complement the findings of the surveys executed within the framework of this project.

Review of distributed generation technologies: In addition, an informal review of relevant distributed generation technologies was executed, i.e. no formal written document was prepared although significant amounts of information were gathered and synthesized [for inclusion into section 9: Future Work] as it became apparent that a solution combining waste treatment and energy generation is desirable from both a technical and economic point of view. This newly gathered information and knowledge and understanding of the issues associated with distributed generation will enable the partner institutions to initiate future projects in this field, whether as part of a comprehensive waste treatment/energy generation package, or as an alternative to the current centralized energy generation model employed today. Indeed, such a project has already been developed and funding is currently being sought to evaluate the potential for distributed power generation throughout the Palestinian Authority as a more economical and socially equitable alternative to establishing central power plants as part of the plan to rehabilitate the Palestinian electricity infrastructure.

Economic analysis and final report: Furthermore, as part of the final report, a full economic analysis integrating the results of the social, industrial, and waste composition surveys was prepared and is included with this final report. That analysis will be distributed to the partner organizations for further dissemination to other relevant stakeholders throughout the region.

Conference: Due to the political and security instability in the region, the joint Israeli-Palestinian conference presenting the findings of this project could not be held. Logistically, bringing Israelis and Palestinians together at a common location was impossible, and as such, it was decided that as the conclusions drawn from the research were oriented towards the establishment of facilities in the Palestinian Territories, it was most desirable to organize and hold a conference in Bethlehem on December 21, 2003 to at least disseminate the results to the Palestinian stakeholders. Furthermore, the dire need for waste treatment solutions in the Palestinian Territories following almost three years of violence and destruction gave such a conference further imperative. Follow-up initiatives resulting from this conference could then be channeled towards relevant Israeli partners by the two Palestinian partners to this project, PIES and WEDO.

During the workshop discussions, a number of issues were raised by the participants in terms of the current situation, future plans and possibilities, as well as in terms of who is supposed to do what in this sector.

It was clear as indicated by the participants that there is a governmental (official) role and duty to be carried out as a pre requisite to any other possible activity, and that it is essential that this field be placed near the top of the list of priority actions at the national level, and that immediate action must be taken at the legal level to facilitate the implementation of the recommendations of this workshop or any other related workshop.

In particular, participants stressed the following actions and recommendations:

1- Waste recycling is an integrated part of a comprehensive waste management system based on waste reduction, recycling and reuse.
2- All agree that good quantities of recyclables are disposed of every day, both in the domestic as well as industrial waste streams.
3- The Palestinian Authority should take immediate measures to develop and finalize the legal requirements for waste recycling procedures.
4- At the same time, the Standards Institute should develop and finalize the recyclables standards at the national level.

5- The participants call on the private sector to initiate waste recycling activities, and also call on the Palestinian Authority to implement incentives to encourage the participation of the private sector.
6- The Environmental Quality Authority should play its role as monitor and inspector in this field, and be active in the formalization of the law and standards.
7- The public knowledge of recycling possibilities and potential was found to be positive, but further work in this area is still needed. The NGO community, as well as governmental institutions, should join hands to strengthen this knowledge.
8- It was recommended that recycling should be in small plants scattered all over the West Bank and not within one central plant in the area.
9- Regional cooperation is an added value possibility, but only for a limited and selected number of recyclables.
10- Recycling should start and initiated through a number of small trial pilots on a range of recyclables starting with those of possible economic values.
11- While recognizing the importance of recycling, it was recommended that those recycling processes that put further pressure on the local environment or resources, especially water, should be avoided in the immediate future; this is most relevant vis-à-vis the water-intensive recycling of newspapers.

8. Project Productivity

The success of this project can be measured using two approaches: either by evaluating the final results of the execution of the activities vis-à-vis how they were described [or proposed] in the original project proposal, or by evaluating the actual results of the activities able to be executed under the actual circumstances encountered during the project execution period.

Not all of the activities originally proposed could actually be executed due to the significant change in the political and security environment between the time when the proposal was prepared and submitted, and when the project was actually executed. The outbreak of the Intifada several months before the project execution period began required a significant adaptation on the part of the project partners to enable the project to go forward.

For example, the field *waste composition survey* completed by the Palestinian students had to be executed under the umbrella of the Palestine Academy of Sciences without any mention of the joint Israeli-Palestinian cooperation element. While this was not an ideal situation in terms of advancing cooperation, the fact that all the partners were able to organize an alternative means to continue with a key activity of this project represents a major accomplishment in light of the very difficult situation at the time when cooperation of any kind was frowned upon on both sides and could also be physically dangerous for the Palestinian partners.

An additional example: the *steering committee meetings* which were supposed to take place through face-to-face meetings could not be held because of severe travel restrictions and so e-mail and phone calls between various participants had to be relied upon instead, so losing to some degree the positive effect of bringing Israelis and Palestinians together, again, a key goal of this project. However, individual meetings were held between various partners as the situation enabled, and through the extra effort required to enable these meetings, a certain dedication and bond was developed that has actually resulted in the preparation and initiation of several additional projects between the partners – as well as additional institutions – in a number of fields, including mental health and energy. This is clearly a major, positive accomplishment and very much represents a success of this project.

Another of the goals of the project was to determine the viability of decentralized physical infrastructure development [as an alternative to centralized infrastructure development] vis-à-vis the dual tendency in the Palestinian sector towards, on one hand, political centralization such that decision-making occurs at the highest level, while on the other hand, decentralizing and fragmenting the various power bases to create a situation of dependence by the local authorities on the central authorities, i.e. local power bases need to get authorization from the head of the Palestinian Authority before executing policy. The reason for executing such a review was based on the concern that any decentralized waste treatment or power generation asset would be viewed in a negative light by the central authorities because such infrastructural assets were typically "controlled" by a single body "close" to the key decision makers. The decentralization of such assets, it was thought, may be perceived as opening the way for possible disruption in the traditional decision-making and power relationships between the stakeholders traditionally involved and thus any project proposing decentralized infrastructure development might encounter political resistance.

However, the severe political upheaval during the project execution period made such a political analysis impossible and any conclusions reached irrelevant as the state of constant flux and uncertainty in terms of who actually has power over how events are controlled was completely unclear and subject to great debate within both the Israeli and Palestinian communities at large. As such, this analysis as described above was not executed. However, as mentioned elsewhere in this report, a technical-only analysis of the viability of decentralized power distribution technologies as part of a hybrid waste treatment/energy generation solution was executed through an informal (i.e. not prepared into a final document) review. Following examination of case-studies from other countries, and consultation with project partners as well as outside experts, it was decided that distributed power generation assets that take advantage of the waste by-products of waste treatment (landfill gas and biogas, for example) are technically viable regardless of the political situation. [A follow-up technical project has already been initiated to evaluate the feasibility of distributed power generation (independent of the waste treatment infrastructure) as an alternative to the establishment of a centralized power generation plants and the accompanying transmission and distribution lines.]

Concern about political intervention in future decentralized-oriented projects has been largely allayed over the last couple years as the international community has demanded, and increasingly received, greater accountability and transparency regarding all funding channeled to the Palestinian Territories, whether through the Palestinian Authority directly or to other organizations working in the region. As such, there is a sense that the installation and operation of distributed power generation technologies at locations of national importance (hospitals, schools, government offices, industrial parks, etc.) by business frameworks operating independently of but in cooperation with the relevant authorities, and supported by the international aid and donor community, would most likely not meet political resistance since a pre-condition for the implementation of any work plan would be full accountability, transparency, and a commitment to refrain from excessive intervention by political authorities.

To conclude, while certain elements of this project were not executed as originally planned, the overall goals of this project were indeed realized – closer cooperation between stakeholders, the execution of the various technical surveys, and identification and development of follow-up opportunities.

9. Future Work

In addition to the more detailed project proposal below, the following options either should also be considered, or are already being developed into practical projects:

A. Technology Transfer:

- It is recommended that only environmentally friendly technologies be transferred to Palestine.
- Any transfer of technology should be linked with proper training courses on such technology use.
- Polluting or excessively energy consuming technologies should be avoided.
- The private sector should be encouraged by incentives to be part of the technology transfer process.
- Material re use and recycling should be integrated into the design and incorporation of new industrial frameworks in the future by actively seeking to leverage economically viable opportunities for the use of these materials in the manufacturing processes.
- Industrial managers should have a wide ranging knowledge of recycling possibilities.
- Joint visits to programs under implementation should be considered to stimulate ideas for appropriate technology application.

B- Environmental Standards and Regulations:

- Pending the finalization of the Palestinian Environmental Standards, internationally approved standards should be adopted in Palestine: in the meanwhile; the countries capacities and companies should be assisted to meet such standards.
- No locally prohibited products, and/or primary or intermediate materials should be allowed into the country.
- Agreements should be made for the mutual recognition of standards between Palestine and Israel as well as other regional countries.
- By-laws and regulations should be completed, along with the establishment of monitoring and enforcement mechanisms and agencies.

C. Awareness raising and education in the industrial and domestic sectors:

- Publishing sector-specific instructions and educational material for the industrial, agricultural, and domestic sectors, as well as for municipalities, on recycling possibilities.
- Approaching the general public for participation in small scale/ household level recycling.
- Organizing a region-wide meeting to discuss the findings of this project and explore further steps.

Future work resulting from this recently completed project is most developed in the form of the following proposal. The proposed project represents the continuation of two separate projects executed by researchers associated with the Hebrew University (including the Truman Institute-led MERC-funded project) and partner organizations, and a recently executed UNEP desk-study evaluating the state of the environment in the Palestinian National Authority areas. These studies analyzed the current state of the environment vis-à-vis solid waste, with the goal of also providing recommendations for future actions to ameliorate the situation.

Based on these recommendations and data from these studies, proposed here is the establishment of a pilot plant integrating organic waste-derived biogas and fertilizer generation for sale in the Palestinian market, and the separation, treatment, and sale of non-organic waste materials to the Israeli market. The plant will operate on [initially subsidized] tipping fees, and through the sale of the electricity and compost produced. It will be managed and run on a BOO (Build-Own-Operate) basis by a foreign concern. This model is proposed to take into account the lack of regional security, continued political instability, and institutional ineffectiveness, the key institutional variables that, in combination with high initial capital costs, make such a pilot demonstration project too risky a venture for a private investor(s).

- There are currently no sanitary landfill sites in the West Bank, with lack of access resulting in significant dumping of waste at illegal or unsanitary sites, or just random dumping in riverbeds, etc.
- Solid waste, whereby the waste is collected and processed/disposed of in strategically-located sanitary landfills, should be managed as part of a ***comprehensive strategy*** that takes into account political as well as financial, environmental, technical, and social factors.
- Due to currently inadequate institutional enforcement mechanisms, the system should employ ***sound business principles*** utilizing economic-based financial incentives to maximize participation. The lack of an established service economy/mentality, as well as the lack of enforcement, precludes initially relying on people to pay for the waste removal/treatment service, so necessitating the involvement of an outside financing body. Representative or symbolic payments may be charged through subsidized tipping fees, with full payment for services rendered charged in the future when the situation enables.
- Integrating ***waste management with power generation*** can improve system economics, something of particular importance in a capital-poor environment requiring significant capital investment. Locally-oriented decentralized waste management plans and sites and modular distributed power generation technologies employing cogeneration can be employed at the local level to enable high overall system efficiency and reliability, offer quick return on investment, and minimize the need for [vulnerable and capital-intensive] centralized facilities. For example, in the Palestinian National Authority areas, the rehabilitation of current power generation and transmission and distribution infrastructures, and development of new infrastructure, is expected to cost over a billion dollars using the traditional centralized models. Employing distributed generation can contribute to the establishment of an independent, more self-reliant Palestinian electricity infrastructure that, by using fuel generated from local solid waste in the power generation process, can offer potentially significant immediate and longer-term capital savings. Thus, the immediate sale of electricity offers an immediate revenue stream to contribute to facility financial sustainability.
- The use of small-scale technologies at locally sited facilities offers a contextually-relevant solution for small and geographically separated communities whose ability to transfer goods, products, waste, etc. to centrally located treatment facilities cannot always be guaranteed. As such, the location of these facilities near the respective communities ensures a higher level of access than would fewer, larger, centralized facilities. In addition, it is easier to locate smaller parcels of land on which to establish small sites than it is large plots for large sites, an important consideration in light of land constraints and politically-related zoning procedures.
- The ***significant % of organic waste*** as a proportion of total solid waste in the PT, and its tenability to local treatment across all stages of treatment (from generation to collection to final treatment) – as opposed to other waste products that may require access to wider economies – makes addressing organic waste a logical starting point for waste management. Treated organic waste –whether in the form of liquid fertilizer or solid compost – thus provides a second revenue stream, such that there are three immediate [albeit initially partially subsidized] sources of revenue: compost/fertilizer, electricity sales, and tipping fees.

Accordingly, the goal of this project is to demonstrate how the application of a locally-applied, multi-sectoral, integrated approach to designing sustainable power and waste infrastructures employing decentralized modular technologies and DG-based cogeneration systems can offer a variety of value-added benefits. The project will demonstrate how this potential that can be achieved when applied on the local, regional, and global levels, as well as provide a complete and detailed business plan/model that can be replicated in other regions.

The specific project objectives are as follows:

- Help rebuild destroyed waste and energy infrastructures using a more resilient overall system reliability model, i.e., the shut-down of one decentralized site will not lead to the collapse of the entire system as can occur with a centralized system.
- Improve total infrastructure system efficiency, effectiveness, and reliability, and contribute to the realization of energy and capital savings, by leveraging recently-available modular and decentralized technologies.
- Assist in the reduction of emissions of greenhouse gases, so lessening the impact of anthropogenic contributions to climate change
- Clarify currently uncertain economics, and address market barriers to the adoption of relevant technologies and approaches resulting from lack of awareness and experience, by reducing perceived risks and uncertainties over costs, performance, and potential market acceptance.
- Determine and demonstrate the financial feasibility of establishing a series of appropriately sized decentralized sites at strategic locations throughout the region, as opposed to relying exclusively on a few large, centralized sites only.
- Use the demonstration site to help convince institutional and private investors of similar project feasibility and so ensure project/paradigm sustainability after project funding ceases.
- Use the demonstration site to facilitate the transfer and sharing of practical experience through local and global market development and information exchange in order to help disseminate the environmental, economic, and social/political benefits the model offers on a wider scale.
- Address potential political resistance to cooperation by involving a foreign service provider acceptable to both sides.
- Contribute to sustainable economic development, job creation, environmental *protection, and conflict resolution* and re-building of conflict-torn communities.

Therefore, this project, to be executed in the Palestinian National Authority areas (PNA), involves:

1. Executing a feasibility study comparing the environmental, technical, social, financial, and political feasibility of generating power through anaerobic fertilizer/biogas generation versus waste-to-energy incineration power generation versus waste-to-compost generation;
2. Identifying appropriate locations for commercially viable pilot demonstration sites employing the relevant power generation and waste treatment technologies;
3. Building and operating demonstration sites;
4. Engaging in information dissemination activities.

For the energy generation element of the project, the demonstration site(s) may employ recently available modular decentralized technologies (possibly microturbines) that offer numerous benefits over traditional centralized infrastructure plants. The use of decentralized waste-to-energy incineration technology, and modular, small-scale fertilizer/biogas generation technology integrating distributed generation (DG) microturbines can allow for the use of a waste generated in the provision of one service to be used as a fuel for the provision of another service, in order to increase overall system efficiency and reliability, improve environmental quality, allow for economically sustainable development, and contribute to regional/local cooperation by providing a framework for community building and conflict resolution. These sites will also contribute to remediating the current situation whereby the lack of properly built and operated waste disposal sites results in arbitrary dumping. For the fertilizer/biogas option, biogas-powered microturbines employing cogeneration systems will be installed and operated at organic waste decomposing sites where biogas/methane will be generated to operate the units for combined power generation and heating/cooling. The waste gasses will provide the fuel to generate power, while the waste heat from the units will provide the "fuel" for building heating, digester temperature stabilization, etc. For the waste-to-energy model, organic waste (and possibly other waste streams) may be incinerated to generate power, while cogeneration technologies can use the waste heat created to provide heating/cooling. Both models will [ideally] be financially self-sustaining after project funding ceases, as well as replicable globally; this will be determined through the economic feasibility review.

Technical Discussion

The characteristics and advantages of modular distributed power generation (DG) technologies [technologies located at or near the end-user's location] are such that they can often be employed in combination with decentralized waste treatment facilities and programs in order to improve overall system technical efficiency, reliability, and cost-effectiveness. In particular, the use of cogeneration and combined heat and power (CHP) technologies across waste and power applications means that the use of a waste generated in one infrastructure service process can be leveraged as a feedstock for another service. The use of decentralized, modular solid waste treatment sites offers similar benefits as above in terms of project cost-effectiveness, overall system reliability, and wider socio-economic and environmental benefit. In light of the advantages offered by these technologies, this model offers immediate applicability and robustness despite political instability, an important consideration in light of the continuing degradation of the physical and natural environment that can ill-afford awaiting a final resolution to the conflict. This project, as described in the activities section, will demonstrate exactly how the application of these decentralized and modular technologies, systems, and sites can realize these benefits, and so further demonstrate the potential for greater social, economic, political, security, and environmental benefit – that is, a win-win solution with significant value-added for all stakeholders involved.

Technical benefits: Community and/or regional development strategies designed on an individual sector-by-sector basis that neglect to take into account cross-sectoral synergies or overlook symbiotic relationships, whether positive or negative, can result in social, political, or environmental damage, lost system efficiency and inferior service quality, and/or missed opportunities to leverage financial added-value of a given venture. For example, investing heavily in centralized waste or power infrastructures can result in discrimination against a weaker sector or social class that has less political or economic power to determine the site location (e.g. NIMBY syndrome). Or, the decision to use large-scale technologies or build centralized facilities may ostensibly be based on [perceived] short-term economies of scale, but comes at the expense of modular technologies that are actually more efficient and reliable with superior longer-term cost-effectiveness and greater overall systemic reliability, but are ignored in favor of more immediate political considerations and credit garnered through high visibility projects. In the Palestinian National Authority areas [and in Israel to a lesser degree], for example, sub-optimal energy use in many sectors and at the different stages of provision (i.e. generation, transmission and distribution), and often undesirable waste dumping patterns, all contribute to environmental degradation, lost economic potential, social and political friction, and regional instability. Yet, the establishment of a network of waste treatment and power generation facilities integrating modular, environmentally friendly, power generation technologies offers a significant opportunity to address, or contribute to the resolution of, many of these issues. As such, the purpose of this project is to determine and demonstrate the financial feasibility of establishing a series of appropriately sized decentralized sites at strategic locations throughout the region, as opposed to relying exclusively on a few large, centralized sites only.

Social and political benefits: In addition to the clear physical improvements to the power and waste infrastructures, the actual day-to-day implementation of the model (involving local businesses, councils, etc.) encourages community cooperation and understanding, facilitates the more egalitarian distribution of benefits and assets across a wider range of socio-economic classes, and allows for more sustainable economic development and growth while improving the local environment and contributing to improving the global environment as well. Around the world, there are numerous potential "test beds" that readily lend themselves to the application of such a strategy. For example, the successful application of such an approach within Israel, between Israeli and Palestinian villages, and on the seam-line in Ireland, offer very immediate opportunities to validate this model for regional cooperation, conflict-area community re-building, sustainable development and environmental protection, and allow for its future implementation in other regions around the world.

Furthermore, bringing members of different [neighboring] communities together in a *cooperative working environment* – both during the project implementation as well as afterwards once the facilities are operational – can help foster local cooperation and greater understanding while providing a sustainable framework within which issues associated with up-stream/down-stream conflicts between communities can be resolved. To this end, a conflict management mechanism will be included as a contingency measure so that, in the event of a conflict developing at any stage, the project can nevertheless progress based on a solution acceptable to all stakeholders. By testing and validating the feasibility of this approach locally, conflict resolution can be advanced in regions where similar problems – socio-economic and political strife, inter-community violence and distrust, local environmental degradation, security instability – exist in concert with each other with no alternative feasible solution apparent as of yet.

Economic benefits: In addition to the local economic benefits derived through improved infrastructure-related service-provision, by demonstrating the viability and economic feasibility of this business model integrating waste treatment and decentralized power generation technologies that realize a quicker return on investment, the global markets for these technologies that meet the demands for superior waste and energy infrastructure service provision will be expanded. By catalyzing the marketplace for such systems and expertise, improvements in technology efficiency and reliability, accompanied by reductions in unit costs achieved through greater market penetration, will ultimately improve both the global human and natural environment.

Furthermore, this project will contribute to local job creation and economic activity by requiring the foreign service provider who will build and operate the site to work in concert with local businesses employing local workers, both in the project implementation and future site operation stages.

<u>Planned Activities to Achieve Goals</u>

Project activities focus on two elements: technical, and socio-economic.

From the **technical perspective**, *the <u>geographical focus</u> of this project* will be determined in general by the regional/local population center, and refined based both on the interaction of communities within the area upon each other, and vis-à-vis their effects and demands upon local *water, waste, and power infrastructures*. A strategy to integrate waste and power service-provision at the local/regional level will be devised based upon the overlap of those sector- and technology-specific characteristics that can be leveraged and applied to complement or improve the provision of a different service from another sector. To this end, the project will involve designing, building, and operating strategically-located, appropriately-sized decentralized power/waste treatment sites centered around a solid waste treatment/power generation facility.

To realize the successful execution of this project, the following <u>technical activities</u> will be executed:

- Technology review comparing power generation through fertilizer/biogas generation *versus* waste-to-energy *incineration versus* waste-to-compost or other waste treatment processes;
- Technology review of relevant non-organic waste separation/treatment technologies and methods;
- Technical analysis of system design requirements;
- Site identification for location and building of integrated non-organic waste treatment, and organic waste composting/power generation and/or waste-to-energy incineration sites;

- Facility design and legal/planning review;
- (Secure co-funding);
- Build, operate, maintain site; train workers; etc.

From the **socio-economic perspective**, the focus will be on developing an effective community participation mechanism to ensure the sustainability of the sites. This will focus on incentive-based methods for encouraging the population to use the site rather than illegally dump waste. This element is essential in light of inadequate or non-existent institutional enforcement mechanisms.

To realize the successful execution of this project, the following socio-economic activities will be executed:

- Financial, environmental, social, and political analysis of sites
- Build community participation and education and awareness raising program
- *Develop information dissemination program – site visitor center; establish business to* initiate similar projects; conference?

The physical attributes to be demonstrated are:

- Non-organic waste is separated and properly treated/disposed of or sold;
- Organic solid waste content is significantly reduced and an ROI achieved by selling the electricity and fertilizer or compost;
- Methane or biogas from decomposing waste will be used to operate distributed generation generators (gensets) for power generation for local use, thus improving local *power reliability, self-sufficiency, and quality;*
- Waste heat from the gensets will be used to stabilize the decomposition chamber's temperature as necessary for maximal decomposition efficiency; facility heating/cooling; power co-generation, etc.;
- Limited land resources will thus be used more productively by: reducing the land area needed for dumping; offering new employment opportunities; enabling capital generation; creating other on-site business opportunities; facilitating social interaction, etc.
- Decomposed biomass sold/distributed as a fertilizer can improve local soil quality; air quality is improved by reducing emissions of greenhouse gasses; water quality is improved by reducing absorption of organic leachates into underground and run-off water supplies, etc.

Expected Outcomes

- Reduced methane/biogas emissions from municipal waste treatment sites.
- Reduced quantity of organic and non-organic waste in landfills.
- Reduced leachate and pollution penetration of underground water supplies.
- Improved local system energy efficiency and reduced energy consumption through cogeneration; greater infrastructural service reliability; increased local employment.
- Sustainable operating demonstration site.
- Greater local awareness of distributed generation and cogeneration technologies/ systems and their advantages.
- Complete work plan document to facilitate replication of program in other locations.
- Enhanced ability to draw interest in and leverage private financing for similar projects following clarification of uncertainties relating to economics, performance, and market *potential.*
- Institutional and individual capacity building through the development of a network of institutions and individuals who can work together on future cooperative projects.

Project Sustainability

The positive effects of the project will be sustained after funding ceases through the establishment of a for-profit entity incorporating representatives of the project partners. Revenue will be generated through sales of electricity and compost, and through tipping fees. This private company will both operate the site as a profitable entity, and will use the data, information, and experience accumulated over the course of the project to raise additional private capital to fund and engage in further market development for future sites. The focus will initially be local and regional, with the goal of ultimately establishing a global network of similar enterprises, each applying the same basic principles/business model but integrating local particularities to ensure local geographical context-relevance.

The social sciences capital generated by the project (i.e. information about the social, political, and environmental benefits of the model, community cooperation and re-building experience, and knowledge regarding improved service provision) will be disseminated by the government offices and educational institutions involved in the project who will be able to leverage the practical experience and knowledge in on-going activities as well as future projects.

Cost-Benefit Analysis of Waste Recycling in the West Bank based on Supply Characteristics

Abstract

The report is made of a few chapters: The first chapter deals with the economic feasibility of building compost-plants, their size and their location in the Palestinian Authority. The second chapter deals with the possibility of creating energy from in these plants. The third chapter deals with the characteristics of household solid waste and the fourth chapter deals with the characteristics of industrial solid waste.

1. General

This work examines the profitability of separating household's solid waste in the Palestinian Authority in Judea and Samaria, and its possible recycling. The study compares the present situation where all the waste is brought to landfills or dumped; between the desired situation where the waste will be separated at its source (in the household) and recycled. Should the recycling alternative be applied, part of the waste will still be buried in landfills because of the following:

1. Only some of the components are recyclable
2. Public participation isn't high and some household will keep disposing of their waste in the former way.

Basic Assumptions

Population

The study was conducted in the Judea and Samaria regions of Bethlehem, Jerusalem, Nablus, Ramallah, Jenin, Tul-Karem, Jericho and Hebron. The study was conducted among the Palestinian population and doesn't include the Jewish settlements in that area.

	Place of living			
	Urban	Rural	Camp	Total
Bethlehem	8			8
Jerusalem	6			6
Hebron	8	5		13
Ramallah	3	3	1	7
Jericho	2	1	1	4
Nablus	3	4	1	8
Tulkarem	6	3		9
Jenin	9			9
Total	45	16	3	64

Type of recyclable wastes

Recyclable wastes include plastic, glass, metal, white paper, newspaper and organic matter.

The components and quantities of Solid Wastes in the PA are presented in table 1:

Table 1: **Solid Waste Characteristics in the PA**

	Total amount (ton/year)	At present
Plastic	9,898	2.77%
Glass	4,838	1.35%
Metal	7,024	1.96%
White paper	10,681	2.98%
Toilet paper	52,118	14.56%
Organic waste	268,627	75.06%
Other	4,710	1.32%
Total	357,900	100.00%

These characteristics of components and quantities are a result of a survey that was conducted within 130 Palestinian families during one year. According to these results, it is possible to recycle almost all the waste-components, but in fact, part of the waste which is marked as recyclable, isn't (like diapers, for example).

Public participation

We assumed that only 60% of households would be willing to take part in recycling their wastes. A 60% participation rate is considered high based on experience in other countries. A wide-ranging educational program should also be executed, including a follow-up program for an extended period of time to maximize the likelihood that the changes in behavior and attitude resulting from the initial education program become entrenched. Without such supplemental activity, the participating rate might drop drastically. Furthermore, if only part of the waste will go for recycling, the authorities will still have to keep and pay for the landfilling. As such, once the authorities decide on the desired system of waste treatment, the education and follow-up program need to be accompanied by a legal enforcement mechanism as well.

Still, even with a lower participating rate, the economic calculations presented in this study will not change, since the calculation was made per weight unit and not per total amount. It should be noted, however, that if the separation of waste in the households will not be mandatory, then two separate systems – one for collection and one for treatment – will have to be applied in each municipality and this will affect the prices.

Present Disposal Alternative

In this work we assumed that the landfill alternative will stay constant, that is – the locations of the present landfills and the disposal fees are not likely to change within the next few years.

Recycling Alternative

Recycling has two categories:

Organic matter: a compost plant that will be built in the PA will accept the organic waste and make compost out of it, for use by the local farmers.

Non-organic matter (plastic, paper, glass, and metal wastes): will be sent to existing recycling plants in Israel.

Method of Analysis

This study has three parts:

I. Benefit analysis of sending organic matter to a compost plant
II. Benefit analysis of plastic, paper, glass and metal disposal
III. Summarizing the benefits of the recyclable materials

I. Benefit analysis of the compost plant alternative

One big compost plant vs. three small ones

Method

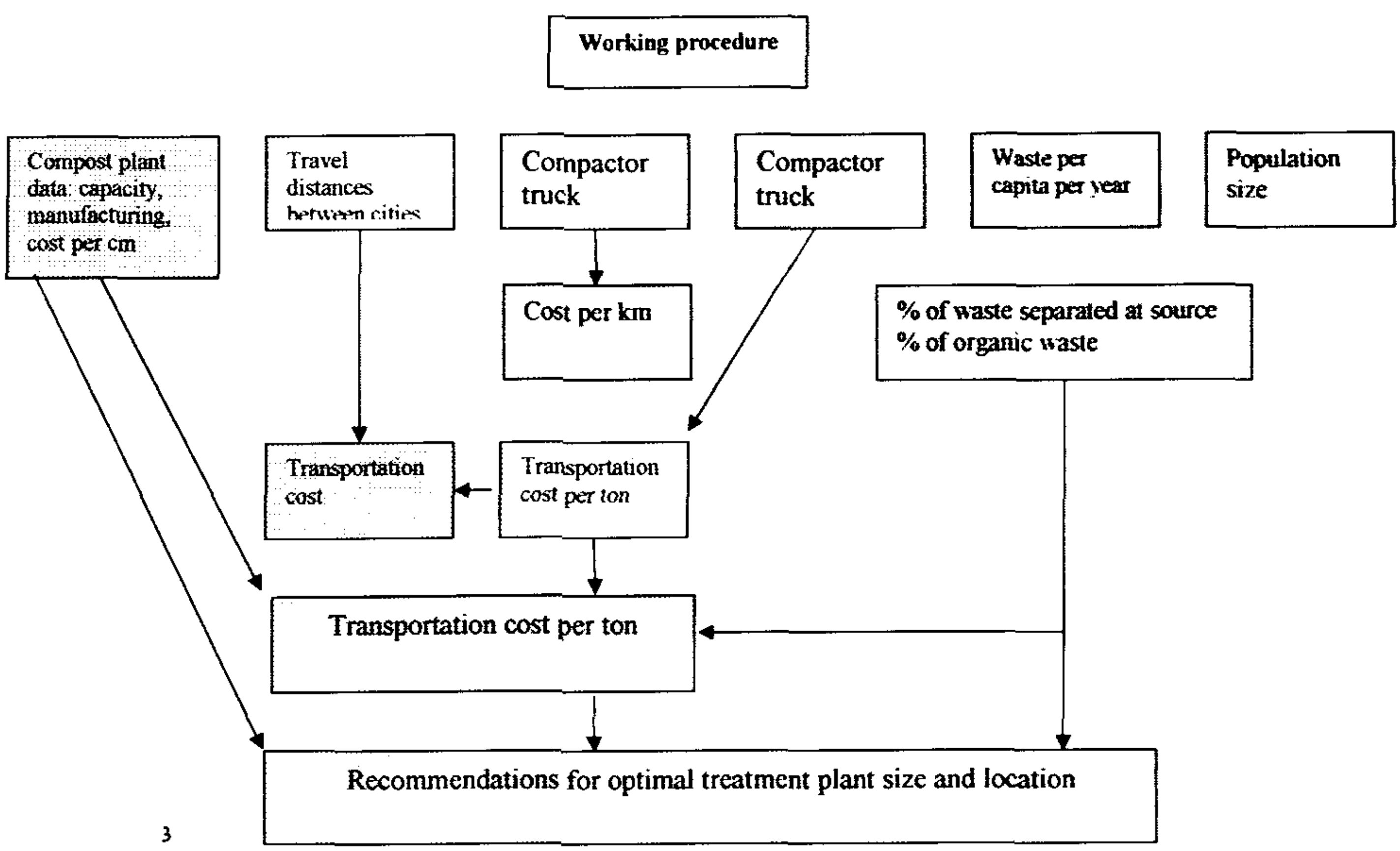
The analysis was based on comparing the savings from a bigger plant (size advantage) with the transport costs to such a plant, vs. three small plants with higher operation costs but lower transport costs due to a closer location to the population.

Working procedure

1. Calculating the treatment-cost per 1 ton in a small compost-plant (30,000 ton compost per year) and in a large plant (100,000 ton compost per year)
2. Calculating transport cost per km and per ton/km
3. Determining the benefits of one large plant vs. three small ones

The procedure is presented in figure 1.

Figure 1: Working procedure



Treatment cost per ton, small plant vs. large plant

Treatment cost in a large compost plant with a manufacturing capacity of 100,000-ton compost per year is lower by about 10 NIS per ton from the treatment cost per ton of a small compost plant with a manufacturing capacity of 30,000 tons per year (appendix 1). 1.66 tons of organic waste is required to generate 1 ton of compost such producing 100,000 tons of compost would require 166,000 tons of organic waste, and 30,000 tons would require 49,800 tons of organic waste.

Transport costs

Condensing trucks are transferring the waste from the city to the compost plant. Cost per km is about 1.14 NIS per ton/km. Since the truck has to go back to the municipality after disposing of the waste at the plant, the cost of disposal to a plant, which is 1 km far from the city, is 2.28 NIS for the round trip (appendix 2, table 2).

The size advantage

To compare the benefits of one large plant vs. three small ones, the calculation was based on the following data:
The treatment cost in a large plant is higher by 3.33 NIS/ton from the treatment cost in a smaller plant.
Most of the cities are at a travel distance of tens km from each other (see map 1). The amount of waste in each city is presented in appendix 3. That means, that having one large plant will increase total travel distances by tens km, vs. three small plants which will be located closer to the cities.

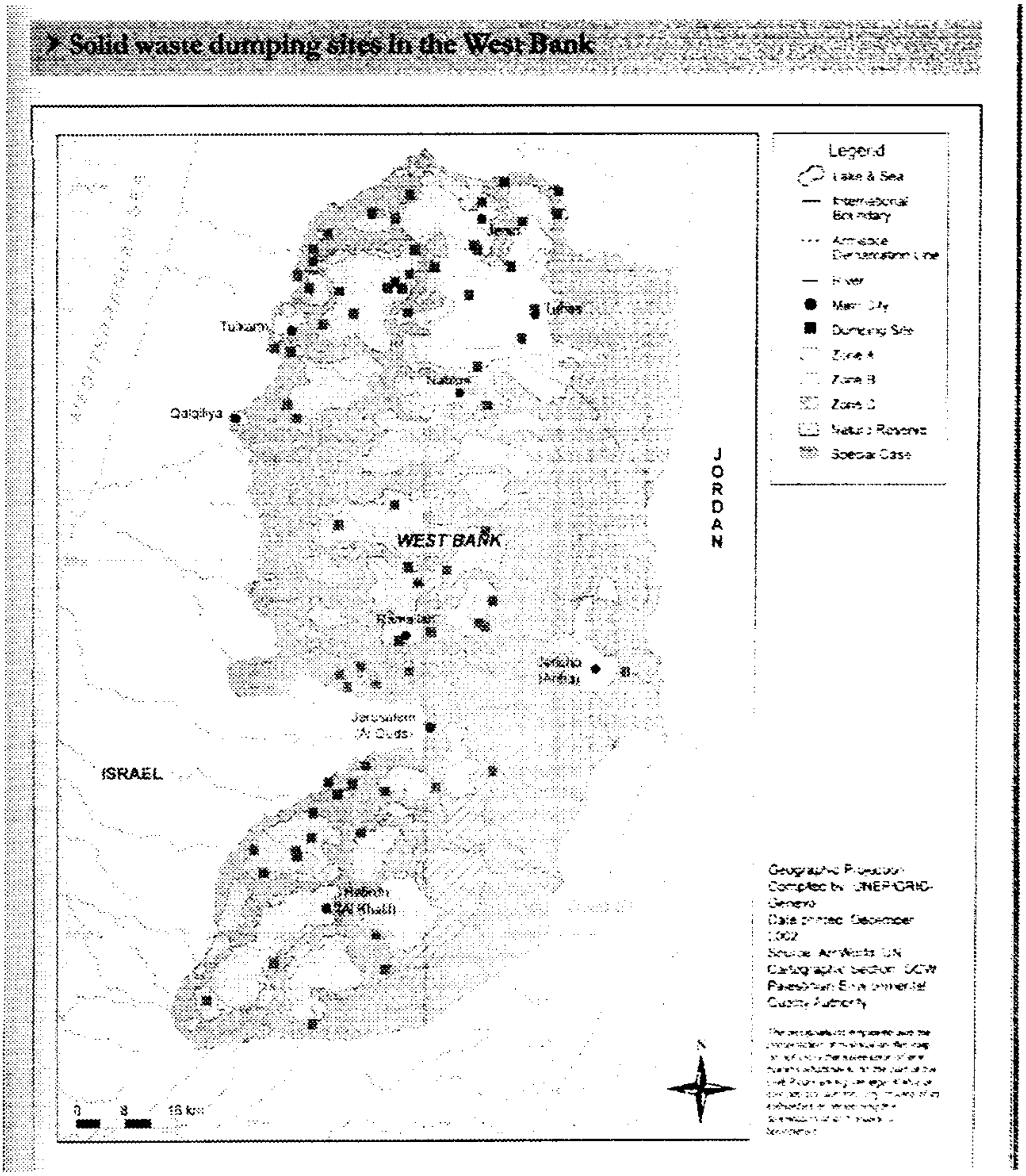
The benefit equation:

$$C/mc(L) - C/mc(S) < Km(L) * 2 * 1.14NIS$$

Where:
C/mc(L) = treatment cost per cm in a large plant
C/mc(S) = treatment cost per cm in a small plant
Km(L) = travel distance to a large plant

Since cost ton/km is 2.28 NIS, should the travel distance exceed 4/4 km, the savings from a smaller plant.

Map 1: Travel distances between the cities



[Map taken from UNEP Desk Study on the Environment in the Occupied Palestinian Territories, 2003]

Location optimization
Optimization procedure for three small plants was conducted as follows:
<u>First stage</u>:
Aggregating all geographically close cities into groups that can supply a total of 30,000-ton compost per year.
The groups are as follows:
Jenin, Tul-Karem and Nablus: 31,000 cm compost per year
Ramallah, Jerusalem, Bethlehem and Jericho: 37,000 cm compost per year
Hebron: 30,000 cm compost per year.

Solid waste item	Average/capita/year Kilograms	%
Plastic	36.71	2.74
Glass	16.48	1.23
Metal	27.56	2.06
Writing Paper	41.27	3.08
Toilet Paper	167.17	12.48
Organic	987.414	73.71
Other	63.033	4.7
Total	1339.637	100

<u>Second stage</u>:
Optimization the location of the plant was the second stage. The purpose of the calculations was to find the location that will minimize the transport costs. It is worth noting that the parameter of waste quantity should also be considered, not only the transport distance. If the quantity is larger, more truck-trips are required. In other words, it is imperative that the multiple sum of the waste quantity with transport distance will be minimum Calculation according to the following equation:

Minimum transport cost to the plant from various close cities (A, B, C,...) equals the total cost of transferring various waste quantities to various distances.

Jenin, Tul-Karem and Nablus
The lowest cost in the case of these three cities would be to locate a plant at Dir-Sharf junction, which connects them. According to the calculation, the average transport cost per ton is 59.8 NIS (appendix 3).

Jerusalem, Jericho, Ramallah and Bethlehem
The optimal location for these four cities is at North East Jerusalem. According to that, the average transport cost per ton would be 18.4 NIS (appendix 3).

Hebron
The amount of waste produced in Hebron is enough to support a 30,000-ton plant. Therefore it's worth locating the plant in the outskirts of the city (appendix 3).

2. Recycling vs. landfill disposal

General:

In this chapter we would like to compare the cost of landfill disposal vs. separating waste into its components (glass, paper, etc.) and transferring them to recycling plants In Israel.

The comparison is made from the point of view of the municipality, and includes transport costs, treatment at a transit station (if necessary or required) and tipping fee.

There are usually three alternative ways to treat solid waste: one is to transfer the waste directly from the city to a landfill or a treatment plant. The second is to collect separated waste from the city neighborhoods, transfer it to a transit station where it is being crashed and condensed, transferred to a larger transport-vehicle, which can't enter the city, and transferred again to a recycle plant. The third is to sort the waste at the transfer station.

It is worth noting that the treatment cost of non separated waste at a transit station is higher than the treatment cost of separated waste at the transit station, due to higher environmental requirements (such as avoiding contamination of ground water with leaches), a cement platform, for example.

It is profitable to operate a transit station in situations where transport distances to the final location are high. Transport cost of 1 ton/km from the city in a condensing truck is 1.14 NIS, whereas transport cost of a truck with 36 tons capacity is 0.43 NIS per ton/km. A rough calculation shows that if the transport distance exceeds 20 km, it is better to use a transit station.

We will show the calculation for each waste component, and the distances to the final destination, that will determine whether it is economically profitable to have a transit station or to transfer the waste directly to the recycling plant.

Landfill:

According the data we got, there are several landfill operating at present by the municipalities. Most of these landfills are not sanitary and don't obey standard environmental requirements. The disposal cost is made of transport cost of about 40 NIS for the round trip, and a tipping fee of 20 NIS per ton, which comes to 60 NIS to dispose one ton of domestic solid waste.

Compost:

1. Compost will be sent to a separate trash collection bin at an average cost of 6 NIS per ton (appendix 4).
2. Transport cost in a compacting truck is 26 NIS per ton (appendix 2 – calculation transport cost in a condensing truck).
3. Payment cost to the plant (the required cost to bring the plant to the threshold of economic profitability) is 15 NIS (appendix 1).

The calculation doesn't include cost of collecting the waste because it is the same whether the waste goes to a landfill; therefore it was dropped from the calculation of this alternative and from the calculation of the landfill alternative.

Total cost for sending the waste to the compost plant is 47 NIS per ton.

Plastic:

1. Plastic bottles will disposed at a separate trash collection bin at an average cost of 70 NIS per ton (appendix 4).
2. Plastic bottles will be transferred to central collecting locations by trucks of 10-11 ton capacity. Those spots will be near the compost plant
3. Transport cost to the transit station is 35 NIS per ton, and the cost of transit station is 35 NIS per ton.
4. Plastic bottles will be transferred to an existing recycling plant T Ramat Hovav, Israel. It's an average of 100 km travel distance. Since the cost /km in a 36 ton truck is about 43 agorot, and with the assumption that the truck returns empty, the total cost of transferring one ton of plastic is 85 NIS. It should be noted, however, that in Ramat Hovav only transparent bottles are accepted.
5. The recycling plant pays 400 NIS per ton of plastic bottles. Therefore, the municipality has a profit of 195 NIS/ton.

Metal:

We got the data from "Dan Michzur" plant in Haifa and "Yehuda Pladot" in Ashdod.

1. The metals will be sent to a separate trash collection bin at an average cost of 1.5 NIS per ton (appendix 4).
2. Total cost to the plant gate is 80 NIS at present. Metal plant pays about 188 NIS per ton, including transport and download, or 100 NIS per to in case they are doing the transport and download.

Glass:

1. Glass bottles will be sent to a separate trash collection bin at an average cost of 7 NIS per ton (appendix 4).
2. We assumed there is a transit station (at a cost of 15 NIS per ton), and transport cost to the transit station is 26 NIS per ton. The desired destination is Fenitsia plant in northern Israel. Based on available data, we also assumed that the plant would pay 100 NIS per ton of glass. Transport cost to Fenitsia is 100 NIS per ton.

Hence, disposal of glass in the recycle alternative will cost the municipality 48 NIS per ton.

White paper:

1. Office paper will be sent to a separate trash collection bin, at an average cost of 23 NIS per ton (appendix 4).
2. Transport cost in a condensing truck to the transit station is 26 NIS per ton. Condensing cost of paper is 15 NIS per ton. Average transport cost to various recycling plants in Israel is about 60 NIS per ton.
3. The recycling plant pays about 250 NIS per ton.

Hence, the profit to the municipality would be 126 NIS per ton.

Newspaper:

1. Newspaper will be sent to a separate trash collection bin at an average cost of 16 NIS per ton (appendix 4).
2. Transport cost to a transit station in a condensing truck is about 26 NIS per ton. Cost of condensing newspaper is 15 NIS per ton.

3. Average transport cost to various recycling plants in Israel is about 60 NIS per ton.
4. The recycling plant pays about 50 NIS per ton.

Hence, a cost of 67 NIS per ton to the municipality.

Cardboard:

1. Cardboard will be sent to a separate trash collection bin, at an average cost of 23 NIS per ton (appendix 4).
2. Transport cost to a transit station in a condensing truck is about 30 NIS per ton. The cost of condensing cardboard is 15 NIS per ton. Average transport cost to a 70 km distance is 60 NIS per ton.
3. The recycling plant pays about 100 NIS per ton.

Hence, the loss to the municipality is 28 NIS per ton.

Results: Comparing recycling with Landfill

Table 4 shows the disposal costs of various waste components vs. the alternative of a landfill

Table 4: Treatment costs of various waste components (NIS per ton)

White paper	Metal	Newspaper	Glass	Cardboard	Plastic	Compost	Waste component / Recycling
(23)	(1.5)	(16)	(7)	(23)	(70)	(6)	Collection cost
(26)		(26)	(26)	(30)	(35)	(26)	Transport cost in a condensing truck
(15)		(15)	(15)	(15)	(35)	0	Transit station cost
(60)	(80)	(60)	(100)	(60)	(85)	0	Transport cost from transit station to plant
250	188	50	100	100	400	(15)	Selling cost to the plant
126	**106**	**(67)**	**(48)**	**(28)**	**195**	**(47)**	**Profit from recycling**
60	60	60	60	60	60	60	Savings from preventing landfilling
186	166	-7	12	32	255	13	Savings from recycling

One can see that it is worth recycling all waste components but newspaper. This component is also on the threshold of being economically profitable should it be recycled. If we had taken the negative externalities which are involved in the landfill alternative (40 NIS per ton) we would see that recycling newspaper is also economically beneficial.

2. Biogas Analysis

The profitability of Methane Recovery in a compost plant

Methane is a gas that is produced during the anaerobic decomposition of organic matter. It can be recovered for fuel, by collecting it in a gas-storage tank for use as fuel that provides power for an engine or a turbine, and therefore can be used to produce electricity.

Methane has an important role in our efforts of using alternative energy source, both because we can use less fossil fuel and because using it has hardly any environmental harmful effect (it burns to carbon dioxide and water).

In this chapter we will examine the profitability of energy production with Methane vs. fossil fuels such as coal and fuel oil.

Direct costs:

Cost of producing 1 kWh with methane: 14 cents per kWh

Cost of producing 1 kWh with coal or fuel oil: 24 cents per kWh

Externalities:

Using methane has an advantage of lower emission of contaminates to the atmosphere, as seen in table 5, although due to the high temperature of methane combustion some NOx is produced from the reaction between nitrogen and oxygen.

Table 5: Emission according to energy source

Coal			Fuel-oil			Methane			
Cost		Source	Cost		Source	Cost		Source	מזהם
c/kWh	gr/kWh		c/kWh	gr/kWh		c/KWh	gr/kWh		
0.463	1,015.00	3	0.390	855.00	1	1.80	4.0*	2,4	CO_2
0.597	1.18	3	2.177	4.30	1				SO_2
0.950	1.70	3	2.065	3.70	1				NOx
0.000			0.011	0.25	1				CO
0.160	0.30	3	0.053	0.10	2				PM
2.170			**4.696**			**1.80**			**Total**

- For estimation purposes we took the value higher than the 2.4-4.0 range

Data source:
1. MOE (2002)
2. Holland, Berry (1998) (ExternE)
3. CIEMAT (1997) (ExternE)
4. Eumania

Estimating the economic damage from air pollution was done according to studies conducted in Europe and in the USA. Table 6 shows the values that were chosen for this study. These are not absolute values, rather they vary according to population, damage to property and according to the method used to estimate the damage. Nevertheless, over time and among different countries, the values were similar, except the damage value from CO_2 emission since it isn't local. In the case of CO_2 the values are in the range of 4/6-138 $ per ton. In order to obey the conservative principle, we chose the lower value.

Table 6: The values of economic damage from air pollution

Source	Contaminant	Damage $/ton
ExternE (1998)	CO_2	**4.6**
ExternE (1998)	SO_2	**5062.8**
ExternE (1998)	NOx	**5581.2**
DOE, 1998	CO	**432.0**
ExternE (1998)	PM	**5301.6**

Conclusion:
Table 7 shows the total costs for kWh production from various energy sources. One can see that the savings from using Methane is due to savings in both direct costs and externalities

Table 7: Total costs of energy sources

Direct costs		**Externalities**		**Total**
	Cent/kWh		Cent/kWh	Cent/kWh
Methane	14.0	Methane	1.800	25.80
Fossil fuels	24.0	Coal	2.170	26.17
		Fuel-oil	4.968	28.97
Savings per kWh	10.0		0.370-2.896	10.370-12.896

3. Solid Waste Supply in the PA Households

These are results of a study that was conducted among 109 families during a period of 12 months, from November 2001 to October 2002.

Socio-demographic characteristics of the study area:

Variable	Average/characteristic description		Comments
Place of residence	More than half of the surveyed people live in a city.	55% live in the city; 32% live in rural areas; 13% live in refugee camps.	Categorical variable: 1 – city, 2 – rural; 3 – refugee camp
Geographic characteristics of place of residence	Most of the people live in a mountain area.	60% live in a mountain area; 26% live in the plane; 5.5% live in the valley; 8.3% live in the Dead Sea area; 15 live in a desert area.	Categorical variable: 1 – mountain, 2 – plane, 3 – valley, 4 – Dead Sea, 5- desert
Major product of the area	Most people live in an agricultural area.	55% in an area that most its product is agriculture; 32% institutional; 6% industrial; 2% tourist; 2% herdsmen area; 3% industrial and institutional.	Categorical variable: 1 – agriculture; 2 – industry; 3 - tourism; 4 – herdsmen; 5 – institutional; 6 – 2 and 5
Major income source in the area	Most of the people are hired workers (employees) and farmers.	40% hired workers; 335 farmers; 16% labor men; 5.55 industrial workers and others are a combination of all categories.	Categorical variable: 1 – agriculture; 2 – industry; 3 – work 4 – employment 5 – 2 and 4; 6 – 1 and 3 and 4

Socio-demographic characteristics of the sample

Variable	Average /characteristic description		Comments
Age	49.6 average age	Range of ages: 20-70	Continues variable
Education	Most people have more than a high school education	46% university degree; 14% college degree; 22% high school degree; 12% elementary education; 6% no formal education	Categorical variable: 1 – no formal education; 2 – elementary education; 3 – high school education; 4 – college education; 5 – university education
Persons per household	An average of over 6 people per family	Between 2 to 14	Continues variable
No. Of families with members with special needs	Over 90% of the families don't have a member with special needs	One family has 2 disabled members; there are 7 men and 4 women who are disabled in the sample.	Continues variable
No. Of providers in the family	Most families have at least one provider	2% of the families don't have a provider; 565 of the families have one provider; 34% have 2 providers; the rest have between 3 to 5 providers.	
Relation to the main provider	In half of the families the father is the sole provider.	50% of the families the father is the sole provider; 15% the father and the mother; 14% the father and one of the sons/daughters; 65 brother or sisters; the rest – other.	
Family income	Most of the people have a good income (over 2000 NIS)	57% have a good income (over 2000 NIS); 35% average income (1000-2000 NIS); 7% low income (under 1000 NIS).	Categorical variable: 1 – under 1000 NIS; 2 – 1000-2000 NIS; 3 – over 2000 NIS

US

The present method of waste disposal

Variable	Average/characteristic description		Comments
Waste disposal from household	Municipal container	79% bring the wastes to the municipal container; 19% dispose into plastic bags, 3% throw it outside; no one burns the waste.	Categorical variable: 1 – burning; 2 – municipal container; 3 – plastic bags; 4 – throwing away
Responsibility for disposal	In most places the municipality is responsible for the disposal.	94% the municipality; 4% no one is responsible; 2% UNDP	Categorical variable: 1- municipality; 2 – private organization; 3 – no one; 4 – UNDP
Collecting frequency by the municipality	In most places waste is being collected on a daily basis.	56% daily basis; 24% once every 2-3 days; 18% once a week; 3% never.	Categorical variable: 1 – daily; 2 – every 2-3 days; 4 – weekly; 4 - never
Payment for collecting waste	An average of 80.75 NIS. Half of the people pay up to 12 NIS.		Continues variable

Knowledge on recycling issues

Variable	Characteristic	Description	Comments
Knowledge about reuse	Half of the people were familiar with the subject.	495 had no knowledge on the subject. Most people associated it with reuse of glass and plastic bottles. 7.5% associated the issue with organic matter.	Open ended question
Knowledge about reuse of wastes	Most people have no knowledge on the subject.	73% are not familiar with the issue. Those that are familiar with it associated it with reuse of food containers and soft drinks. 6% associated reuse with organic matter.	Open ended question
Willingness to separate waste at home	Most people are willing to separate wastes at home.	79% are willing to separate wastes at home, the rest are reluctant due to inconvenience.	Open ended question
Willingness to use recycled wastes	Most people are willing to use recycled waste.	87% are willing to use recycled waste.	Open ended question
Recycled materials you are willing to use	A quarter is willing to use any recycled material?);	24% are willing to use any recycled material; 25% are	Open ended question

	Most of them are willing to use more than one recycled material.	willing to use recycled paper; 25% are willing to use glass; 70% are willing to use more than one material. Only 1.8% is not willing to use recycled materials.	
What will encourage you to use recycled waste?	More than half said that protecting the environment is one of the reasons to use recycled waste.	52% said protecting the environment; 24% said reducing waste volume; 21% said saving money; 10% said protecting resources.	Open ended question
Knowledge about compost	Most have knowledge on the subject	Most of the people said compost is made of food wastes; 38% said animal waste; 7.5% said household and organic waste; 20% have no knowledge on the subject.	Open ended question
Livestock	Most people don't have livestock	785 don't have livestock	
Fire wood	Most people don't have a wood-heater	89% don't use fire wood for heating	
Other recycling countries	Most people have no knowledge on the subject	55% don't know about other recycling countries; others mentioned the USA, Europe, Israel, Jordan and Japan as recycling countries.	Open ended question
What do you think are the recyclable materials?	40% chose not to answer this question	Paper, glass, metal, plastic and others.	Open ended question
What is your opinion about recycling	All people have a positive opinion on recycling		Open ended question
Waste hole (or pit)	Most of them don't have one	26% do have one	

We can see that there is a great willingness to cooperate with the recycling idea, whether by having a positive opinion on the matter or by using recycled products, or even by participating actively in separating wastes at home. In many cases, the willingness to cooperate increased with increase in knowledge and awareness. In this case we can see a high level of willingness to cooperate in spite of the fact that many people said they lack the knowledge.

We can examine the potential of making compost in the area of the study, by looking at the data collected. We would reserve our analysis by saying that many of the parameters in the questionnaires are categorical or representing a state of mind, therefore they are only showing a trend, not a quantified measure.

Parameters affected the ways of handling waste (regression)

Variable	t value	B
Coefficients	6.156	1.836
Source of area income	2.427	0.007
No. Of waste collection	4.275	0.208
Accept using recycle products*	-2.083	-0.275
Have wood heater*	2.555	3.41

Rsq= .288 Std Error= .42 F=10.307

Sig=. 000

* Dichotomy variable: 1-yes; 2- no.

As expected, the areas socio demography data (income, services dealing with garbage) affected waste disposal manners.

Parameters affect the milling to separate waste (regression):

Variable	t value	B
Coefficients	5.487	1.577
No. Of workers	-2.532	-0.107
Rate of waste disposal	2.141	0.087
The amount pay for waste disposal	-2.62	-0.00075
Willing to use recyclable products*	2.296	0.297
Raise cattle*	-2.263	-0.19

Rsq= .252 Std Error= .3

Sig=. 001 F=4.922

* Dichotomy variable: 1-yes; 2- no.

It seems that the willing to separate garbage rise as the rate of waste collection decline (1-evry day; 4-never), possibly to decrease the waste volume. As expected, the willing to use recyclable products affected positively.

Parameters affect the milling to use recyclable products (regression):

Variable	t value	B
Coefficients	8.434	1.624
Family income	3.339	0.149
Way of waste disposal	-2.408	-0.15
Use wood heater	2.113	0.262

Rsq= .165 Std Error= .3

Sig=. 000 F=6.467

The income levels correlate to the willing to use recyclable products. When the income level increases the willingness to use recyclable products also increases.

4. Industrial's Solid Waste:

Wool and clothes industry

12 plants were surveyed. 3 in Hebron district, 3 in Beit Lehem district, 1 in Jericho district, 1 in Ramallah district, 3 in Jerusalem district and 1 in Jenin district.

The area of the plants ranged between 20-3000 m2 with an average of 900 m2. The working areas are often only a small fraction of the plant's size. In most cases the working area is at least half of the plant's area. The storage areas are in most cases 30% or less of the plant's area. Most plants don't have additional area.

The employees in the plants were divided according to the type of employment: administration, engineers, technicians and laborers, as well as by field of expertise.

Between 1 to 9 employees are typically employed in administration, while in half of the plants there is only one manager; in 3 plants there is a woman in an administrative position. Only 1 plant employs an engineer. The number of technicians (men & women) is between 0 to 25. The number of employees is between 0 to 100. Most employees are women.

The main raw materials, cloth and thread, are from Israel and Turkey. There is a difficulty in estimating the quantities because of the mix up in reporting the units (length, weight, volume, etc.); in general the quantity can be estimated between several to a few hundred tons.

Most plants do not posses hazardous substances, although a few do posses flammable materials. The packaging materials (if in use) are bags or nylon bags.

The storage is in the plant or in a storage room, usually with no time limit.

The leading product is clothes of different types, packed in plastic bags. Hazard (if it exists) is from fire.

Two plants reuse products, which they fix and resell.

Most waste consists of pieces of material and residues of threads, their quantities are estimated between ¼ - 27 Tons. Additional waste: plastic, aluminum, cardboard and plastic packages. In most cases the municipality collects the waste. The cost of waste disposal is 140 – 5600 NIS/year, with 1546 NIS/year as average.

One plant reported recycling of material residues and another one indicated a potential for waste recycling. Material residues are sold at 5 or 3 shekels/meter.

Others gave a negative answer, claiming that recycling is not their expertise or not suitable. One plant gave a location excuse. Even when a plant indicates the presence of materials for recycling it often has an excuse why recycling is not suitable for them.

Food industry

26 plants were surveyed. 3 in Hebron district, 3 in Beit Lehem district, 4 in Jericho district, 3 in Ramallah district, 3 in Jerusalem district, 3 in Nablus district, 5 in Tul Karem district, and 8 in Jenin district.

The plants are very different in their size. Their area is between 40-14000 m2. The average plant area is 1810 m2. Half the plants operate in an area of 350 m2 or less. The working areas are often only a small fraction of the plant's area. In more then half of the plants the working area is 150 m2. In 84% of the plants, the working area is up to half of the plant's area, while in an average food plant the working area will be about 40% of the plant's area. In most cases the storage areas will occupy 200 m2.

88% of the plants don't have any storage areas. Most plants don't have additional area. This might be due to the fact that some of the plants are family business, and that most of the plants are small workshops rather than real well organized plants.

The employees in the plants were divided according to type of employment and מגדר : administration, engineers, technicians and laborers. Between 1-7 men and 0-4 women are employed in administration, while in half of the plants there is 1 manager. An average plant will employ 2 persons in administrative duties, only in 4 plants a woman is employed in the administration. In 65% plants there is no engineer. There are no women engineers. Only 1 plant employs female technician. Most plants employ 2 technicians. The number of employees is between 0-34, most employees are males, most plants (61%) employ 5 workers.

The main raw material flour, grain, seeds, sugar, eggs, olives, vitamins, milk and plastic packages are from local production or from Israel. Here too, there is a difficulty in estimating the quantities due to a mix up in the units, although most units are in ton/yr. In general it can be said that the quantity us from few tons (and less) up to thousands tons. Most plants have no possession of hazardous substances, 2 plants possess caustic soda and one of them also ammonia. The packages (if there are any), bags and nylon packages. The storage, usually under cooling, in plastic containers, bags or special packages in the plant's area or store room. The storage is for a short time, safety equipment usually covers protection from fire, some plants possess also special clothing. The leading products: olive oil, different kinds of bakery, drinks, different kinds of milk products and food for cattle in quantities estimated from hundreds to thousands of tons.

The plants collecting back products are the milk products producers, taking back spoiled products and discarding them as waste. The quantity range is from small quantity in one plant to 54 tons in another; usually the quantity is around 12 tons.

Most of the waste consists of plastic packaging, food residue (solids), cheese water, yogurt and oil residue (liquid). It is hard to estimate their quantities since the data mixes liters, number of packages and tons. Rough estimate is several tons. Usually the waste is collected by the municipal authority, but in some cases it is sold or used for heating. The cost for waste disposal is 100- 50000 NIS/year. In most of the cases, the plant pays an annual fee to the municipality in exchange for the disposal service, whether the waste is solid or liquid, therefore, and unless otherwise mentioned, it should be noticed that the unit is almost in NIS/yr. Most plants chose not to respond in this item.

9 plants sort waste, 7 plants recycle waste products, among the mentioned uses, use of sesame peels (from tahini production) as food sheep and reuse of cheese water in the production processes. 3 plants sell waste, oil precipitates, 50 tons are sold to local ranches and a soap plant (12 JD/ton) and grain peels are grounded again and used to produce black bread sold to bakeries (500 shekels/ton). One plant indicated the recycling of 2 tons/month of grain peels for animal feed. Most surveys' were against on site waste recycling. The reasons: lack of space, lack of budget, quantity is too small to recycle, or not good (one plant claimed that recycling results in a bad name for the plant). 8 plants report the presence of materials for recycling, among them: sesame peels – sheep feed, cheese water, oil precipitates, plastic bottles, all mentioned they need equipment, budget, man-power and special expertise.

Leather industry

6 plants were surveyed, 3 in Hebron district, 2 in Jerusalem district and 1 in Nablus district.

The plants are very different in their size; their area is in the range of 400 to 18000 m2. They can be divided into one very big plant and the rest as small and medium. The working areas represent 30-50% of the plant area. Storage areas, usually occupy 25-60% of the plant area. Half the plants possess additional area of 50-100 m2.

The employees in the plants were divided according to type of employment and field of expertise: administration, engineers, technicians and laborers. 12 persons are employed in the very large plant in management duties and in the rest there are only 1-3 employees in management duties. Only the largest plant employs engineers (9). This plant employs 90 males and 30 females. The others employ 0-7 persons.

The raw materials, leather and synthetic leather, are from local and Italian origin, in quantities between tens to hundred thousands feet per year. Additional materials, such as shoe sole adhesives, chemicals and plastic are from local or European sources estimated in different units. In general and where it was possible, the units for raw materials were in ton/yr.

Half the plants possess hazardous substances including chemicals containing heavy metals, acids and flammable adhesives.

The main raw materials are stored in a storeroom, some in bags without time limit or for a few months.

The leading products are shoes, bags, wallets and clothes. The produced quantity is between 9200 to 5 millions pairs of shoes (or units). The products are stored in nylon bags or cardboard boxes without time limit.

One plant reported reselling or discarding about 1000 pairs of shoes per year.

Most of the waste consists of cardboard packages and leather residues and material from the production process. The quantities are 0.6-120 tons per year.

2 plants reported loss of raw materials: residues of material and leather. In one plant 30 Kg/day with value of 500 shekels are discarded to waste. In another plant 400Kg/day of leather, material and cardboard boxes residue are discarded to waste and 300 Kg of grained plastic is reused in the plant. The waste is collected by the municipality. The cost of waste disposal is 650-20160 NIS/year.

One plant reported sorting waste and recycling waste products (108 tons of grained plastic). Most of the plants surveyed were opposed to on-site waste recycling. The reasons: lack of funds or not suitable. Two additional plants indicated the presence of materials for recycling, naming leather and material residues but the lack of funds prevents them from recycling these materials.

Wood and furniture industry

19 plants were surveyed. 3 in Hebron district, 3 in Beit Lehem district, 2 in Jericho district, 3 in Ramallah district, 4 in Jerusalem district, 3 in Tul Karem district, and 1 in Jenin district.

The plants area is between 60 to 7000 m2. The area of half of the plants is less than 200 m2, 2 plants occupy large area (6000-7000 m2) and the rest are medium. The working areas are about 45% of the total area. In most cases the storage areas are about 40% of the plant's area. 7 plants possess additional area Of 10-1000 m2.

The employees in the plants were divided according to type of employment and fields of expertise: administration, engineers, technicians and laborers. The number of administrative duties holders is 0-6, in 70% of the plants there is one manager. Only 1 plant employs female manager. No plant employs engineers; the number of technicians is 0-8. The 2 large plants employ 15 and 30 workers and in the others the number is 0-10. No females are employed in the wood industry (except the 2 managers).

The main raw material is wood, mostly from local production. There is a difficulty in estimating the quantities due to the mix up of the units. In general it can be said that the quantity range is from a few tons to hundreds tons. Additional materials: material, adhesives, paints, sponge and leather mostly from local production estimated in different units. 5 plants posse's hazardous substances, including paints, adhesives and flammable materials.

The main raw materials are stored as boards on the floor in the plant or in the storage, for a few months. Fire hazard problem was indicated.

The products are different kinds of furniture. The produced quantities are given in non-comparable units (e.g. 15 kitchens are different from 15 chairs). The products are stored with no time limit.

Two plants reported selling returned products.

All the waste is solid, with the main waste consisting of residues of wood and sawdust from the production process. Their quantities are estimated from 0.1 to 60 tons. Additional solid waste includes wood chips and sponge residues estimated between hundreds of Kg to hundreds of tons per year.

Six plants reported loss of raw materials: wood residues, sawdust and chips. The sawdust is sold to chicken farms (few tons per month) and wood chips to for heating (0.5 shekels/Kg). The leftovers of wood, sawdust and material are discarded as waste, sold or given for free. The waste is collected by the municipality; the quantity is estimated between hundreds of Kg to tens of tons. Only 3 plants responded to this question, the prices quoted were between 200-400 NIS/yr, with the fees paid to the municipality on an annual basis.

Half of the plants sort the waste. 4 plants recycle waste products. About half of the plants sell recycled waste product at prices of about 0.5 NIS/Kg depending on the quantity.). Most surveys' were against on site waste recycling. 1 plant gave a positive answer, 200 Kg/month of wood chips. Among the reasons against recycling, lack of funds, space, manpower: small quantity, not suitable or there is already an alternative solution (for chicken houses or heating). 7 plants indicated a will to recycle. 7 plants indicated by products of wood chips and sawdust.

Metal industry

21 plants were surveyed. 3 in Hebron district, 6 in Beit Lehem district, 2 in Jericho district, 2 in Ramallah district, 3 in Jerusalem district, 1 in Nablus district, and 4 in Jenin district.

There is a large variety in the plants' area; the size is between 80-3000,000 m2. The area of half of the plants is less than 1000 m2, 2 plants possess large area (11000-12000 m2) and one very large with 300,000 m2. The working areas are around 50% of the plant area. Storage areas are often ca. 40% of the total. 6 plants possess additional area of 20-100,000 m2.

The employees in the plants were divided according to type of employment and fields of expertise: administration, engineers, technicians and laborers. In most plants there are 2-3 managers, 1 engineer, 3-5 technicians (max.15), 5-9 laborers (max. 30).

The main raw materials: different kinds of metals, steel, iron, aluminum and more, mostly from Israel. The quantity ranges from a few tons to hundred thousands tons. Additional materials: plastic, copper and paints mostly from Israel estimated in various units.

3 plants possess hazardous substances, including hydrochloric acid, fuel and flammable materials. In most cases the main raw materials are stored on the floor in the plan, the possible storage period range between few weeks to unlimited time.

In most plants there is fire-fighting equipment sometimes with proper clothing and gloves. The products include: agricultural or industrial equipment, covering boards, electricity boards, building iron, doors, screens, furniture and jewelry. The quantities are reported in non-comparable units.

The products are stored from a few days to unlimited period.

3 plants recycle products: in the gold plant they recycle 300 Gr/month. In the other 2 plants the quantity is relatively small and therefore not counted.

Most of the waste is solid. 1 plant has liquid waste containing oil and metal chips (ca 960 tons). Most waste contains metal chips from the production process. The quantities are estimated from hundreds of Kg to tens of tons. The disposal cost is 300-9000 NIS/year.

6 plants reported sorting the waste, with another 7 plants claiming to recycle waste products. Around half of the plants sell recycled waste products, residues and pieces of metals to merchants or to Israel. The quantity is up to 56 tons and the prices of 3-6 shekels/ton. Several plants give their waste for free. Most surveys' were against on site waste recycling. The jewelry plant recycles its waste on site. Another plant recycles aluminum. Among the reasons against recycling: lack of funds, space, manpower, know how, or a small quantity of waste that makes recycling not feasible.

5 plants possess by products with values depending on the product, from 7000 JD/Kg gold sold to similar plants to 3 shekels/Kg aluminum sold to merchants.

NOTES

1. In filling the questionnaire, is was requested of the participants toinclude the units where possible, and to use tons/year for raw materials, products and generated waste. But in their response, many gave other units, either because they don't know, or it was easier for them to give other units which are more familiar to them, such as feet for leather or cubic meter for wood. However, in copying down the questionnaires in the tables (inclusion into the computer), attempts were made to unify the units, where that was possible.
2. In general, and unless otherwise mentioned, the units for the quantities of raw materials used, products produced or industrial waste generated were in ton/yr. Units for the cost of waste disposal were in NIS/yr< and very rarely were given in $/yr, which can be also changed to NIS/yr, or visa versa.
3. A Microsoft Excel file is attached which was extracted from the whole industrial survey. In sheet 1 the plants were given according to the District, while in sheet 2 were arranged according to the type of industry. IN BOTH CASES, IT SHOULD BE NOTED THAT JERICHO WAS EXLUDED. This file can be referred to in order to review all the quantities and units used or produced.

Appendix no. 1: <u>big compost plant versus small ones - cost calculation.</u>

According to 100,000 cubic ton compost plant and 30,000 cub ton compost plant calculation:

- 30,000 cub compost plant- if 1 cub compost cost 0 NIS and the compost present value 0 NIS, the local authority will pay 14 NIS per ton of organic waste.
- 100,000 cub compost plant- if 1 cub compost cost 0 NIS and the compost present value 0 NIS, the local authority will pay 8 NIS per ton of organic waste.

Small plant- data, calculation and sensitivity analysis

General

Companies fee	36%
Plant's production quantity	30,000
Required area	70
Land lease cost	300
Capitalization rate	8%

Required investments

Subject	Units	Quantity	Unit cost (NIS)	Total (NIS)
Infrastructure				
Ground preparation	Square meter	60000	10	600,000
Road	Square meter	10,000	75	750,000
Water system	קמפ'	1	150,000	150,000
Sewer	קמפ'	1	300,000	300,000
Surrounding fencing	מ"א	1,400	90	126,000
Signposting and gates	קמפ'	1	25,000	25,000
Odor neutralization system	קמפ'	1	40,000	75,000
Electric infrastructure and control	קמפ'	1	200,000	200,000
Total infrastructure				**2,226,000**
Installations and structures				
Office, service	Square meter	150	1,000	150,000
Laboratory	קמפ'No	Other examination		6,000
Total installations and structures				**156,000**
Equipment and machines				
Trimmings shredder	Unit	1	500,000	500,000
Flooding care system	Unit	1	100,000	100,000
Scales	Unit	1	140,000	140,000
Sieve	Unit	1	300,000	300,000
Tractor.	Unit	1	300,000	300,000
Total equipment and machines				**1,340,000**
Sundries				

Design, erecting, fees	קמפ'	1	200,000	200,000
				200,000
Total investments				**3,922,000**

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Annual operation expenses

Subject	Units	Quantity	Unit cost (NIS/year)	Total (NIS/year)
Land lease cost	Dunam	70	300	21,000
Labor				
Watchman		1	20,000	20,000
Operator		2	30,000	60,000
Director		1	45,000	45,000
Secretary		1	25,000	25,000
Total labor expenses				**171,000**
Operation and maintenance				
Fuel and tractor maintenance				250,000
General (insurance, office, communication)				125,000
Total operation and maintenance				375,000
Total annual current expenses				546,000

Companies fee
Contractual profits
Plant's production quantity
The amount of waste taken care
Required area
Capitalization rate
Waste compost proportion
Waste cost

Compost and waste cost – sensitivity analysis

Waste cost

Present value

0	-30	-25	-15	-5	0	5	10	20	25	30
-20	1142	-222	-4292	-8555	-10686	-12818	-14949	-19212	-21343	-23474
-10	2785	1421	-1725	-5987	-8118	-10250	-12381	-16644	-18775	-20906
0	4428	3064	[redacted]	-3419	-5551	-7682	-9813	-14067	-16207	-18338
10	6072	4708	1980	-851	-2983	-5114	-7245	-11508	-13639	-15771
20	7715	6351	3623	895	-469	-2546	-4678	-8940	-11071	-13203
30	9359	7995	5267	2539	1174	-190	-2110	-6372	-8504	-10635
40	11002	9638	6910	4182	2818	1454	90	-3804	-5936	-8067
50	12646	11282	8553	5825	4461	3097	1733	-1237	-3368	-5499
60	14289	12925	10197	7469	6105	4741	3377	649	-800	-2931
70	15932	14568	11840	9112	7748	6384	5020	2292	928	-436
80	17576	16212	13484	10756	9392	8028	6664	3935	2571	1207
90	19219	17855	15127	12399	11035	9671	8307	5579	4215	2851
100	20863	19499	16771	14042	12678	11314	9950	7222	5858	4494

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Big plant- data, calculation and sensitivity analysis

General

Companies fee	36%
Plant's production quantity	100,000
Required area	200
Land lease cost	300
Capitalization rate	8%

Required investments

Subject	Units	Quantity	Unit cost (NIS)	Total (NIS)
Infrastructure				
Ground preparation	Square meter	180000	10	1,800,000
Rode	Square meter	10,000	75	750,000
Water system	קמפ'	1	300,000	300,000
Sewer	קמפ'	1	600,000	600,000
Surrounding fencing	מ"א	4,200	90	378,000
Signposting and gates	קמפ'	1	60,000	60,000
Odor neutralization system	קמפ'	1	80,000	75,000
Electric infrastructure and control	קמפ'	1	400,000	400,000
Total infrastructure				**4,363,000**
Installations and structures				
Office, service	Square meter	150	1,000	150,000
Laboratory	קמפ'	1	100,000	100,000
Total installations and structures				**250,000**
Equipment and machines				
Trimmings shredder	Unit	2	50,000	100,000
Flooding care system	Unit	2	100,000	200,000
Scales	Unit	1	140,000	140,000
Sieve	Unit	2	300,000	600,000
Tractor.		2		
	Unit		300,000	600,000

		1		
Total equipment and machines				**1,340,000**
<u>Sundries</u>				
Design, erecting, fees	קמפ'	1	200,000	400,000
				6,653,000
Total investments				**6,653,000**

Annual operation expenses

Subject	Units	Quantity	Unit cost (NIS/year)	Total (NIS/year)
Land lease cost	Dunam	200	300	60,000
Labor				
Watchman		2	20,000	40,000
Operator		4	30,000	120,000
Director		1	45,000	45,000
Secretary		2	25,000	50,000
Total labor expenses				**315,000**
Operation and maintenance				
Fuel and tractor maintenance				500,000
General (insurance, office, communication)				250,000
Total operation and maintenance				750,000
Total annual current expenses				1,065,000

Companies fee
Contractual profits
Plant's production quantity
The amount of waste taken care
Required area
Capitalization rate
Waste compost proportion
Waste cost

Compost and waste cost – sensitivity analysis

Waste cost

										Present value
30	25	20	15	10	5	0	-5	-10	-15	0
-53,346	-46,242	-39,138	-32,033	-24,929	-17,825	-10,720	-3,616	1,888	6,434	0
-50,779	-43,674	-36,570	-29,465	-22,361	-15,257	-8,152	-1,048	3,531	8,078	3
-49,067	-41,962	-34,858	-27,754	-20,649	-13,545	-6,440	80	4,627	9,173	5
-46,499	-39,394	-32,290	-25,186	-18,081	-10,977	-3,873	1,723	6,270	10,817	8
-44,787	-37,683	-30,578	-23,474	-16,369	-9,265	-2,161	2,819	7,366	11,913	10
-42,219	-35,115	-28,010	-20,906	-13,802	-6,697	-84	4,462	9,009	13,556	13
-40,507	-33,403	-26,298	-19,194	-12,090	-4,985	1,011	5,558	10,105	14,652	15
-37,939	-30,835	-23,731	-16,626	-9,522	-2,418	2,655	7,201	11,748	16,295	18
-36,227	-29,123	-22,019	-14,914	-7,810	-797	3,750	8,297	12,844	17,391	20
-31,948	-24,843	-17,739	-10,635	-3,530	1,942	6,489	11,036	15,583	20,130	25
-27,668	-20,564	-13,459	-6,355	[redacted]	4,681	9,228	13,775	18,322	22,869	30
-23,388	-16,284	-9,180	-2,075	2,874	7,420	11,967	16,514	21,061	25,608	35
-19,108	-12,004	-4,900	1,066	5,613	10,160	14,706	19,253	23,800	28,347	40

Appendix 2: waste transport in compress trucks – cost calculation

The compress trucks collect the waste. During the collection the waste compresses.

Average truck contains about 15-ton waste.

Data and assumptions

The calculation cost per Km based on:

Annual depreciation: about 109.5 NIS.
Driver's wages (tow drivers a day): 2*2,500=5000 NIS/month.

Burdening worker's wages (2 workers / truck /shift, 2 shifts / day):
2*2*1,500=63,000 NIS/month.

Fuel, oil, tires maintenance (cost/Km): 5 NIS.

Overhead: 10% from all expenses.

Annual drive (Km/ time): 20,000 Km/year. Most of the data done during the collection, therefore the velocity per hour is slow.

Results:

The 15 tons compress trucks collect the waste, inside the local authority.
The data above show that cost per Km is 1.14 NIS/ton/Km. truck has to go back, therefore waste disposal to planet 1 Km far, is 2.28 NIS.

Appendix 3: Location calculation

Jennin Tul Kareem and Nubles.

The shortage rode connected this 3 cities pass Dir Sharif junction. This location minimizes the transport costs. Anther location may decrease the transport costs for one city but increase for the other two. Therefore, although Nubles have the larger quantity of waste, setting the compost plant near Nubles rise the transport cost from Jennin and Tul Kareem. This amount of waste is not justifying location closer to Nubles.

Jerusalem, Jericho bet lechem and Rammala.

In this case the optimal location is ester Jerusalem. The waste quantity in Jerusalem is significance higher then the other two cities. In addition, Jerusalem placed between the three cities. This location minimized the transport cost.

Hebron

The waste quantity Hebron formed is sufficient to establish compost plant inside the Hebron's municipal area.

Appendix 4: store tanks per waste tons- cost calculation

Tank's type	Store volume (liter)	Free time (sec. Without travel)	Acquisition cost (without VAT)	Life term (year)	Annual maintenance expenses (%acquisition cost)	Monthly cost per tank	Waste quantity per tank, monthly (NIS)	Av. Store Cost per ton waste
76	76	7	50	3	0.045	175.40%	0.1	17.95
120	120	10	100	4.5	0.045	258.60%	0.15	16.76
240	240	12	120	5.5	0.045	270.30%	0.31	8.76
360	360	25	240	6	0.045	510.80%	0.46	11.04
660	660	40	700	6	0.045	1489.80%	0.85	17.56
770	770	42	800	6	0.045	1702.70%	0.99	17.2
1000	1000	50	1000	5.5	0.045	2252.8.4%	1.29	17.52
1100	1100	52	1100	5.5	0.045	2478.10%	1.41	17.52
1500	1500	70	1500	4.5	0.045	3879.40%	1.93	20.12
Mean	647	34.22	623.33	5.17	0.05	14.46	0.83	16.05

Store tanks per different waste type tons- cost calculation

Waste types	Volume weight proportion	Average cost per ton
Mix	7	16.05
Glass	3	6.88
Plastic	30	68.79
Compost	2.5	5.73
Carton	10	22.93
Wight paper	10	22.93
Newspaper	7	16.05
Metal	0.5	1.15

Parameter	Value	Calculation		Notes
Truck life term (year)	7	Cost per Km	17 NIS	
Km/time	20,000	Cost ton per Km	1.14 NIS	
Compress truck's cost	500,000NIS			Compress trucks contains about 15-ton
Driver wage (annual)	60,000NIS			2 Driver wage
Sanitation worker wage (annual)	72,000 NIS			2 Sanitation worker wage in 2 shifts
Oil, fuel and tiers maintenance	5NIS			
Annual working capital	109,559 NIS			

Table 3: waste quantity

Parameter	Bet Lechem	Jerusalem	Nabules	Rammala	Jennin	Tul Kareem	Jericho	Hebron	Total
Population	169,317	394,105	318,240	289,827	247,305	335,082	40,849	505,694	2,300,419
Organic waste	17,506	43,672	33,010	33,025	30,024	21,412	8,734	83,791	271,173
Separate	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Cub compost ton proportion	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Organic waste for compost formation (cub/year)	6,327	15,785	11931	11,937	10852	7,739	3,157	30,286	98,015

Waste transport in 36-ton transportation trucks – cost calculation

Parameter	Value	Calculation		Notes
Truck life term (year)	5	Cost per Km	16 NIS	
Km/time	55,000	Cost ton per Km	0.43 NIS	
Compress truck's cost	1,000,000 NIS			transportation trucks contains about 36-ton
Driver wage (annual)	192,000 NIS			2 Driver wage
Oil, fuel and tiers maintenance	7 NIS			
Annual working capital	227,410 NIS			